SAR Wind Imagery After the First Year

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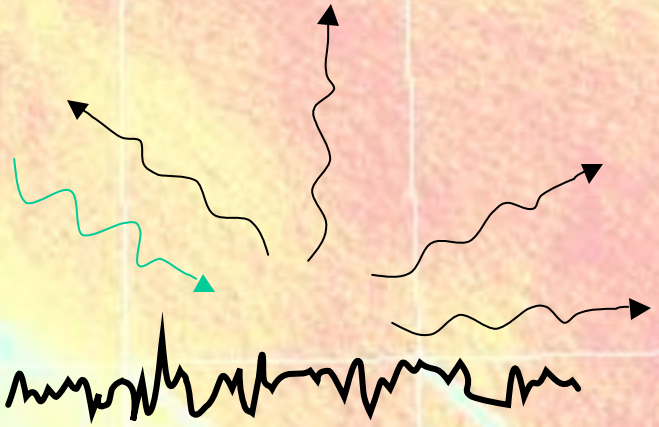
Outline of presentation

- Why would we ever believe that a radar could measure winds?
- Scheme for estimating wind speed.
- Sample wind images.
- Preliminary Validation
  - Models
  - Buoys
- Timing
- Conclusions

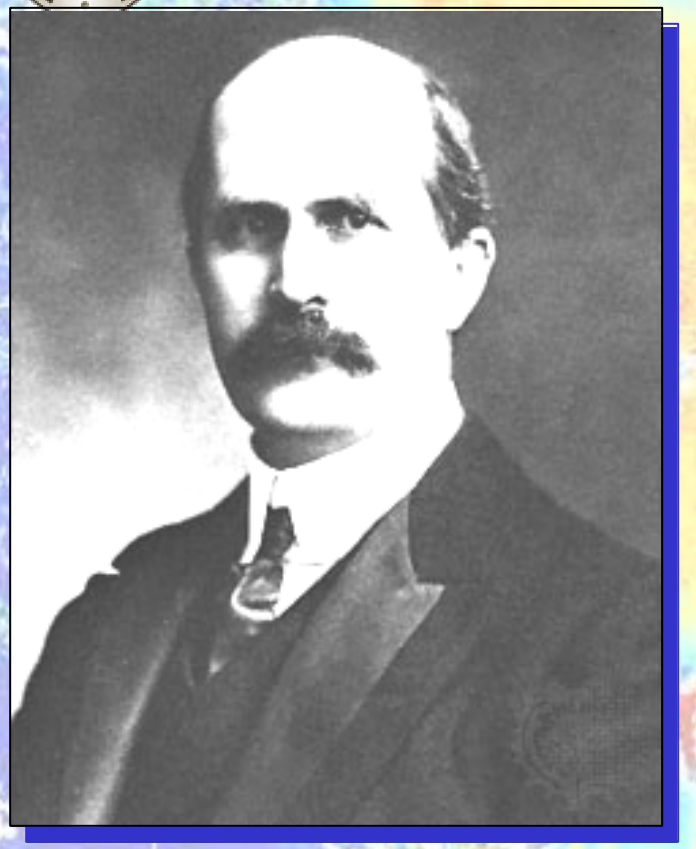
Scattering

Specular scattering from a smooth surface: Most of the energy is reflected away.

Diffuse Scattering from a rough surface: Energy is reflected in all directions.



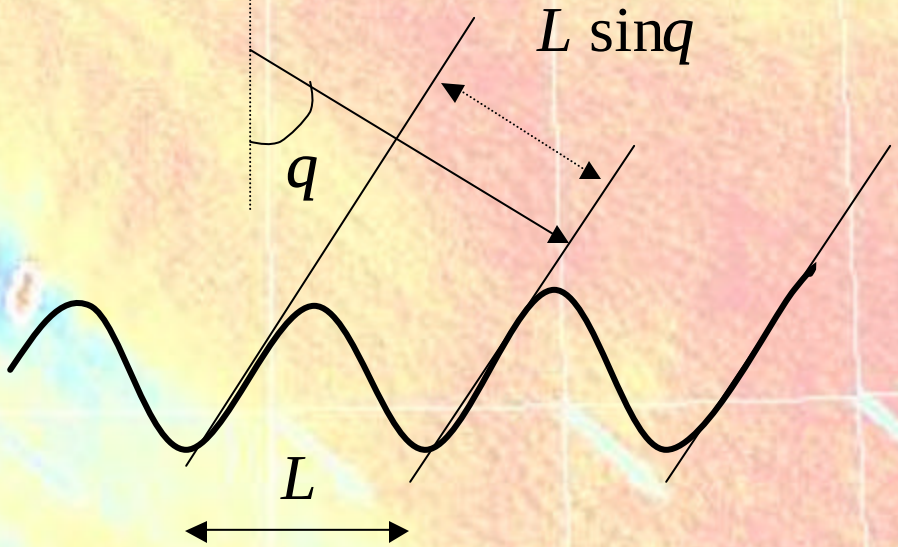
Bragg Scattering



Sir William Lawrence Bragg
Bragg resonance was discovered in the context of scattering from crystal structures.
Encyclopedia Britannica, 1999.

A periodic structure will set up a resonance for waves that match the Bragg condition.

$$l = 2\,L\,\sin q$$



Wind speed model function

$$s_0^{\mathrm{H}} = R(q)\underbrace{a(q)U^{g}\,[1+b(q)\cos f + c(q)\cos 2f\,]}_{\text{CMOD4}}$$

- S_0 **represents radar cross section.**
- U **is the wind speed raised to a power** γ**.**
- f **is the angle between the wind speed and the radar look direction. If** q **is equal to zero then the radar is looking into the wind.**
- a, b, c **are constants and a function of incidence angle** q**.**
- $R(q)$ **is the polarization ratio.**

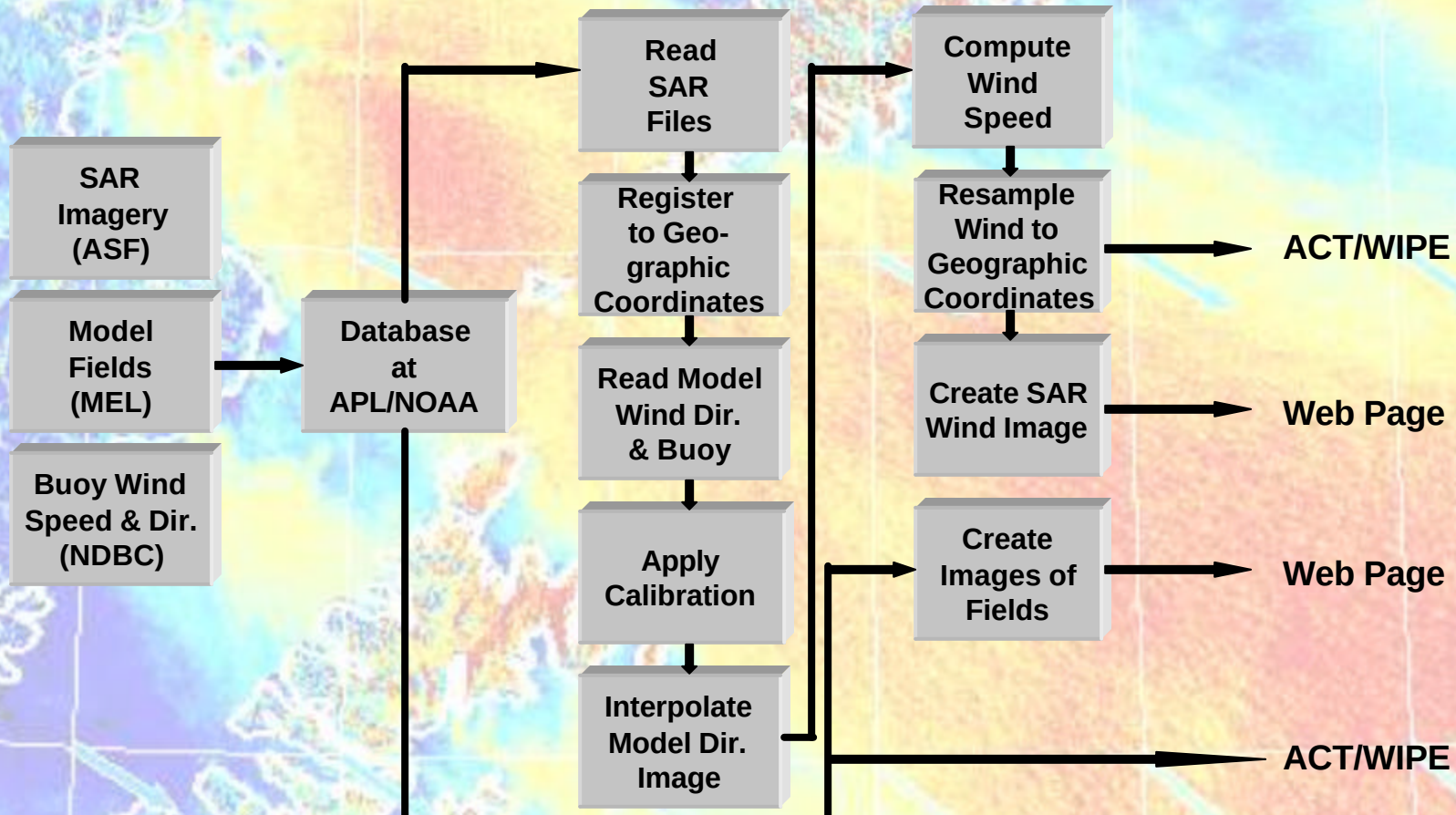
Polarization ratio

$$R(q) = \frac{(1 + a \tan^2 q)^2}{(1 + 2\tan^2 q)^2}$$

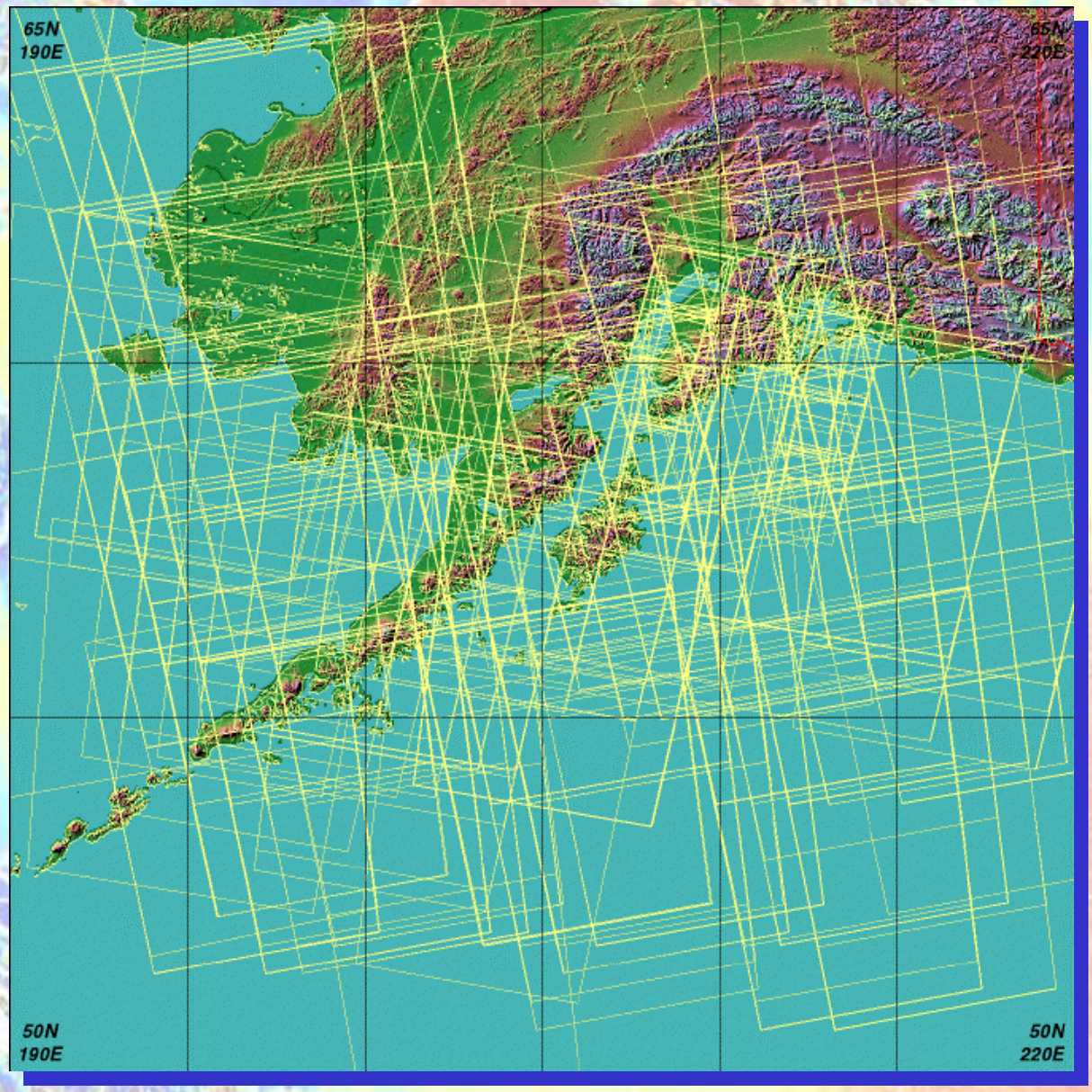
- $a = 0$, **Bragg scattering**
- a **= 1, Kirchhoff scattering.**
- **Using an empirical** $a = 0.6$ **.**

Reference for polarization ratio: Thompson D. R., T. M. Elfouhaily, and B. Chapron, Polarization ratio for microwave backscattering from the ocean surface at low to moderate incidence angles, *Proc. 1998 International Geoscience and Remote Sensing Symposium*, Seattle,Washington, Proceedings, 1671–1673, July 1998.

Wind speed processing



Coverage



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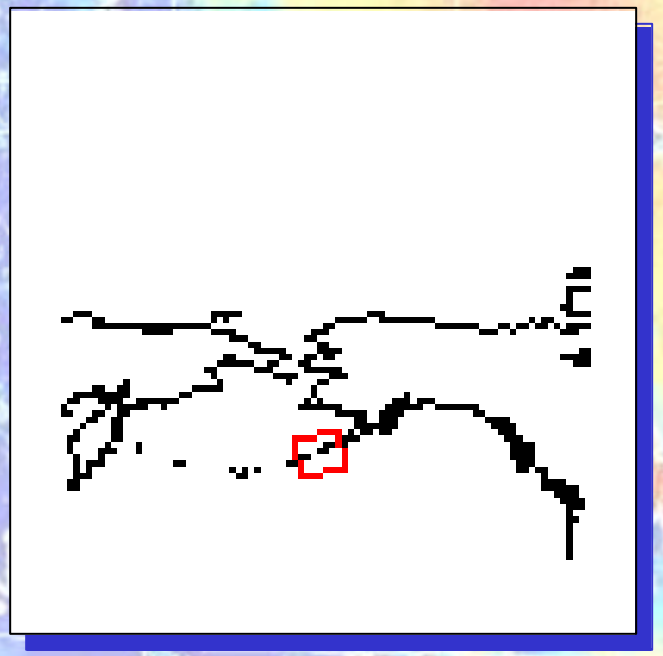
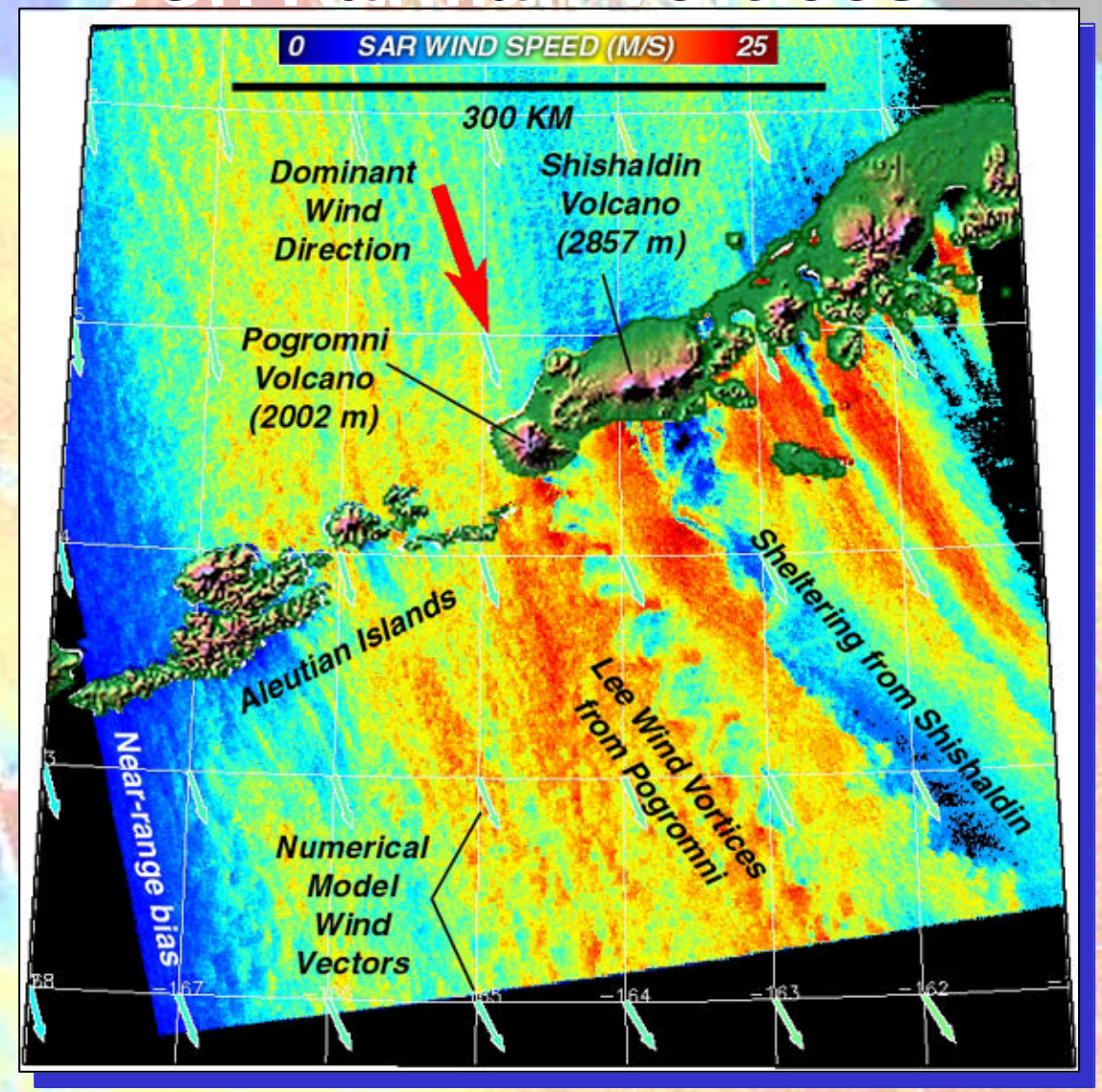
Von Karman Vortices

1999 Dec 22
0442 UTC

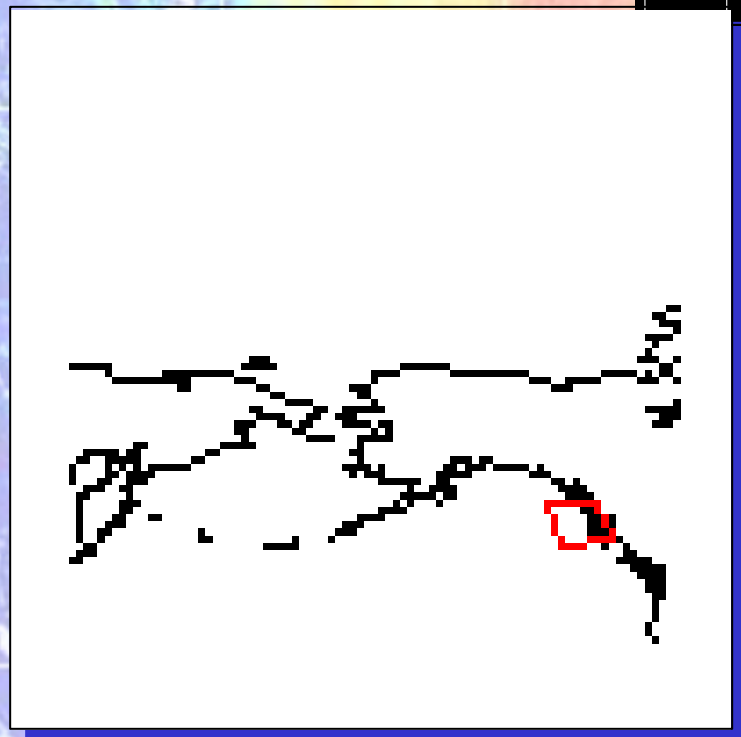


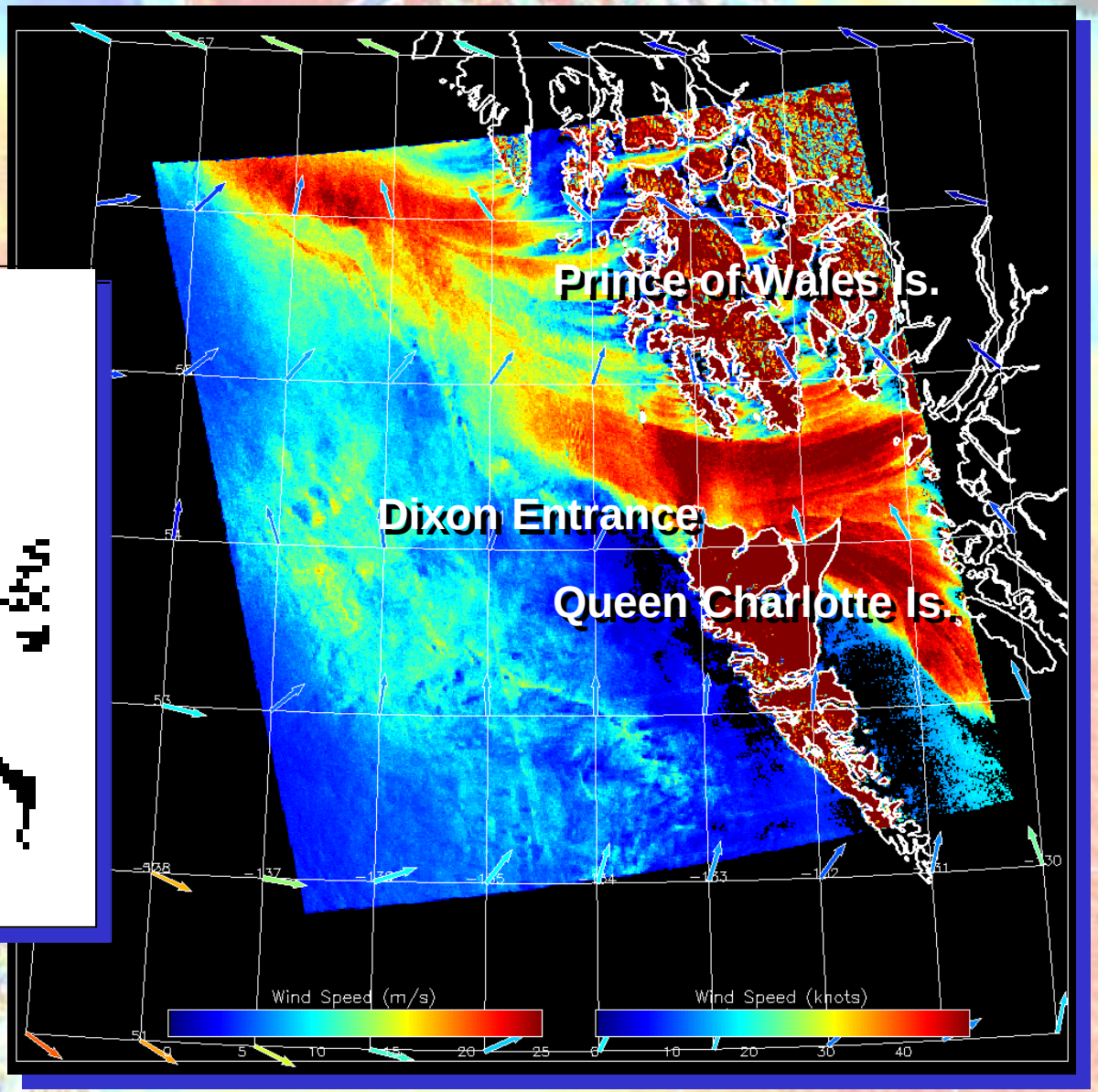


http://orbit35i.nesdis.noaa.gov/orad/sar/

Canadian West Coast

1999 Dec 9
0240 UTC





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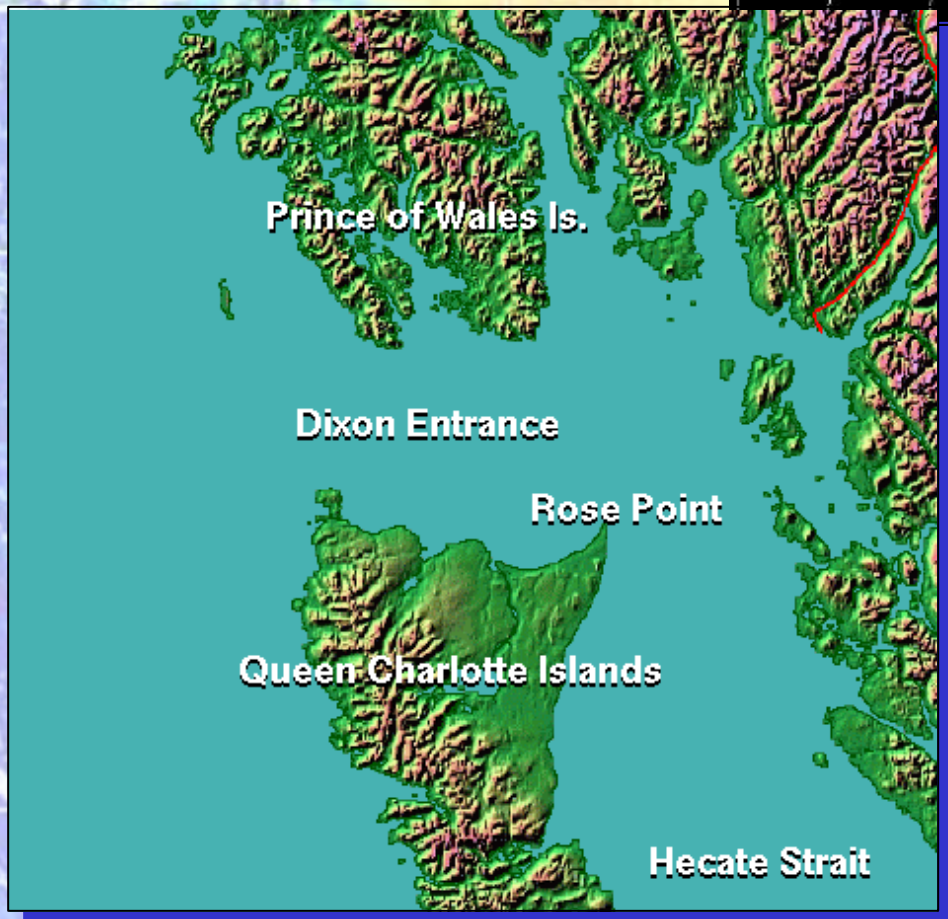
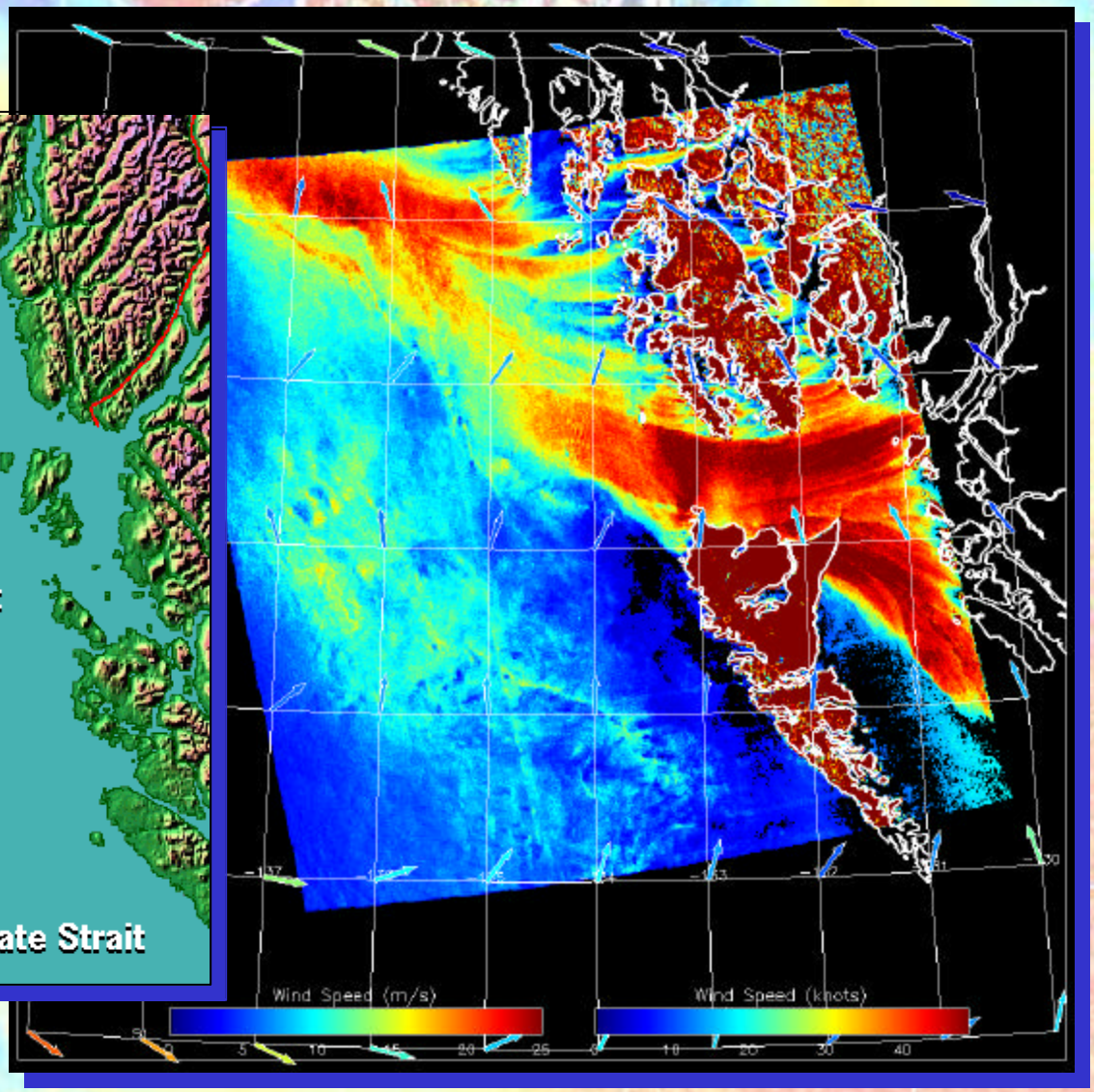
More Canadian West Coast





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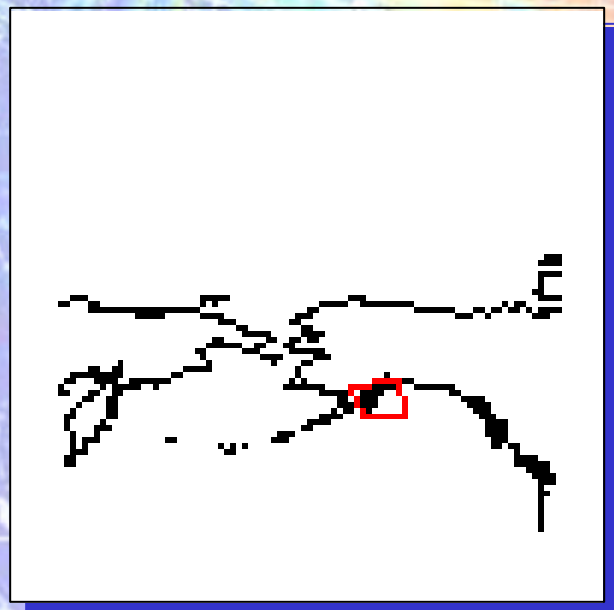
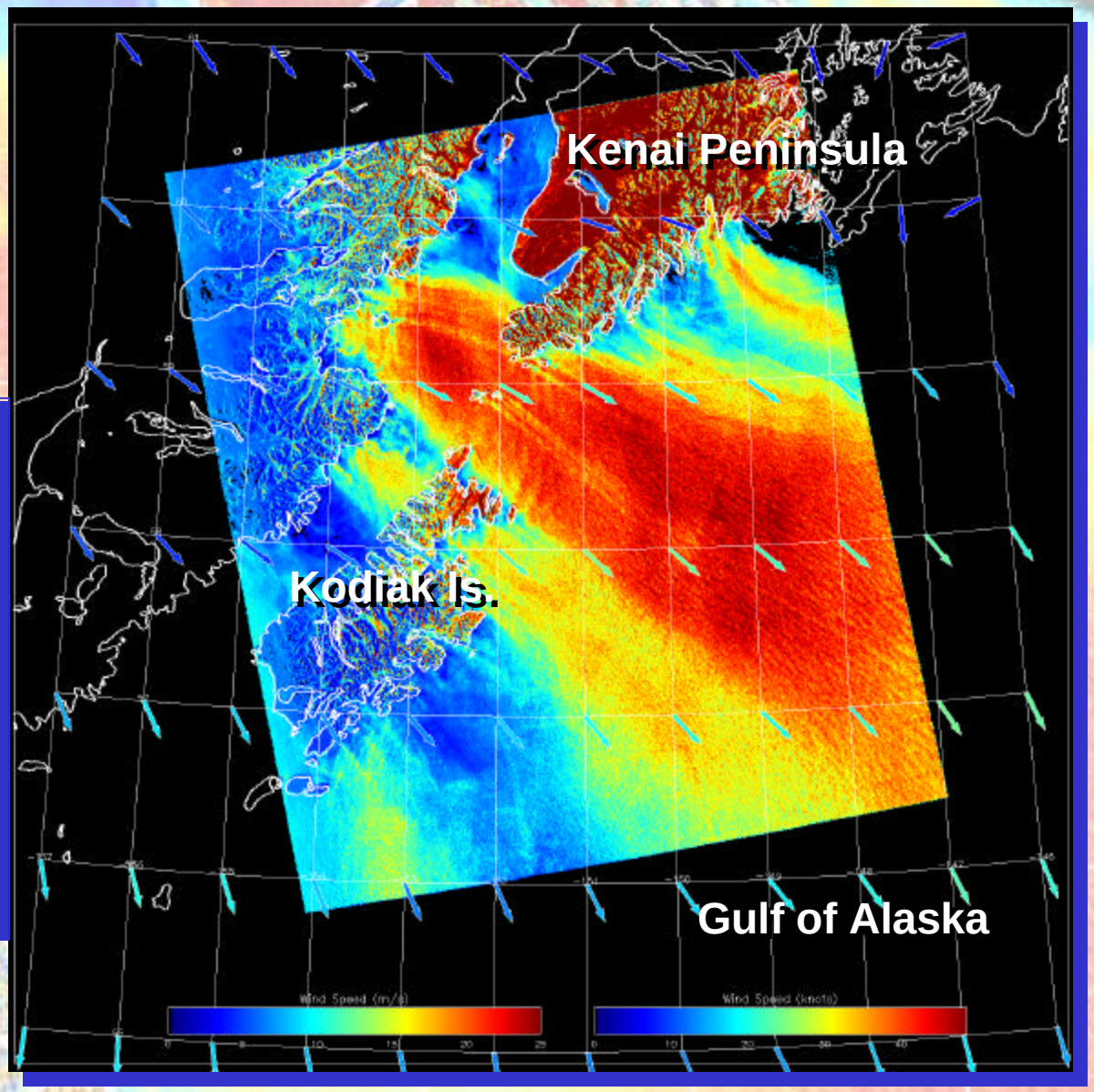
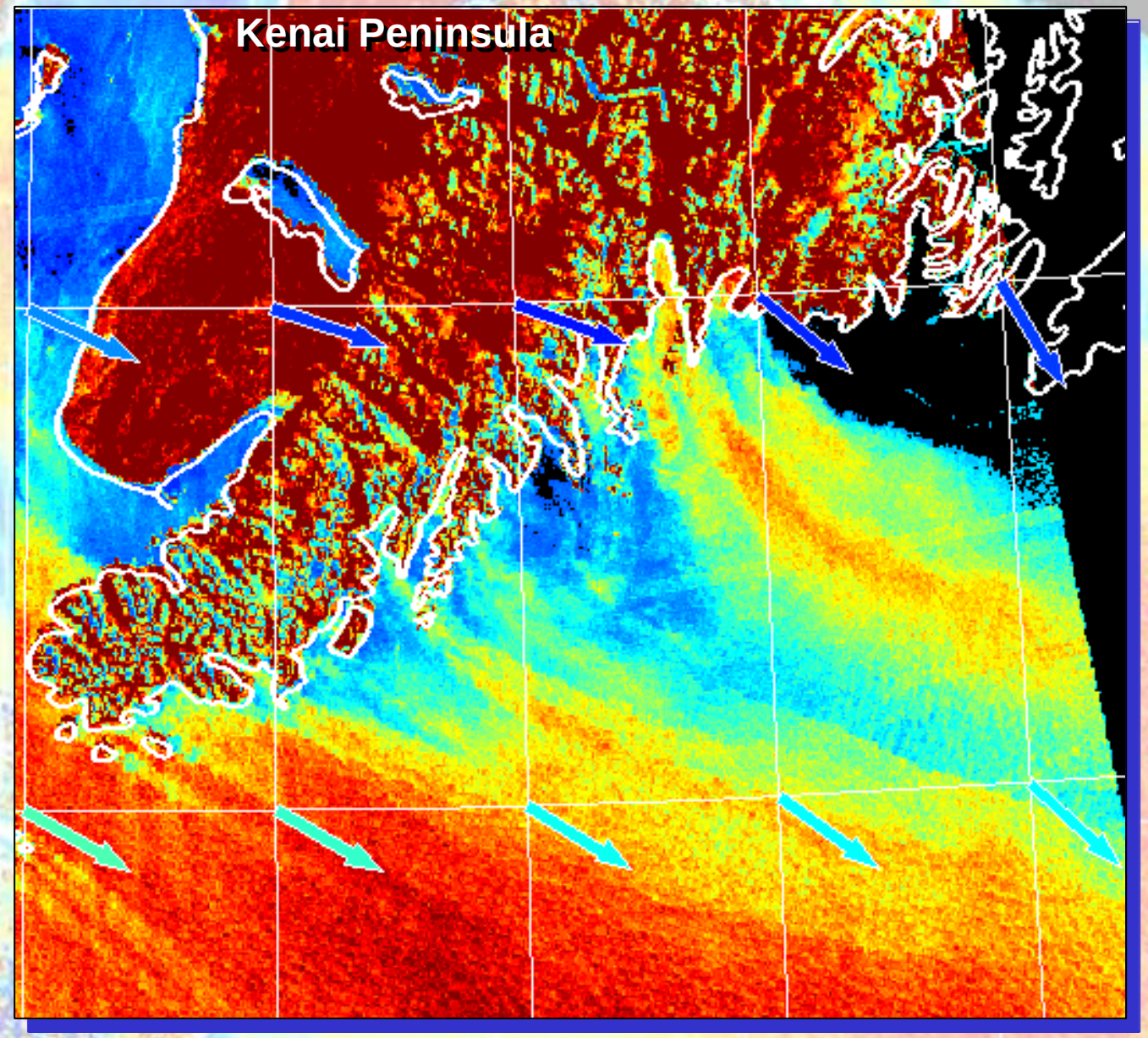
Cook Inlet

1999 Dec 24
0344 UTC





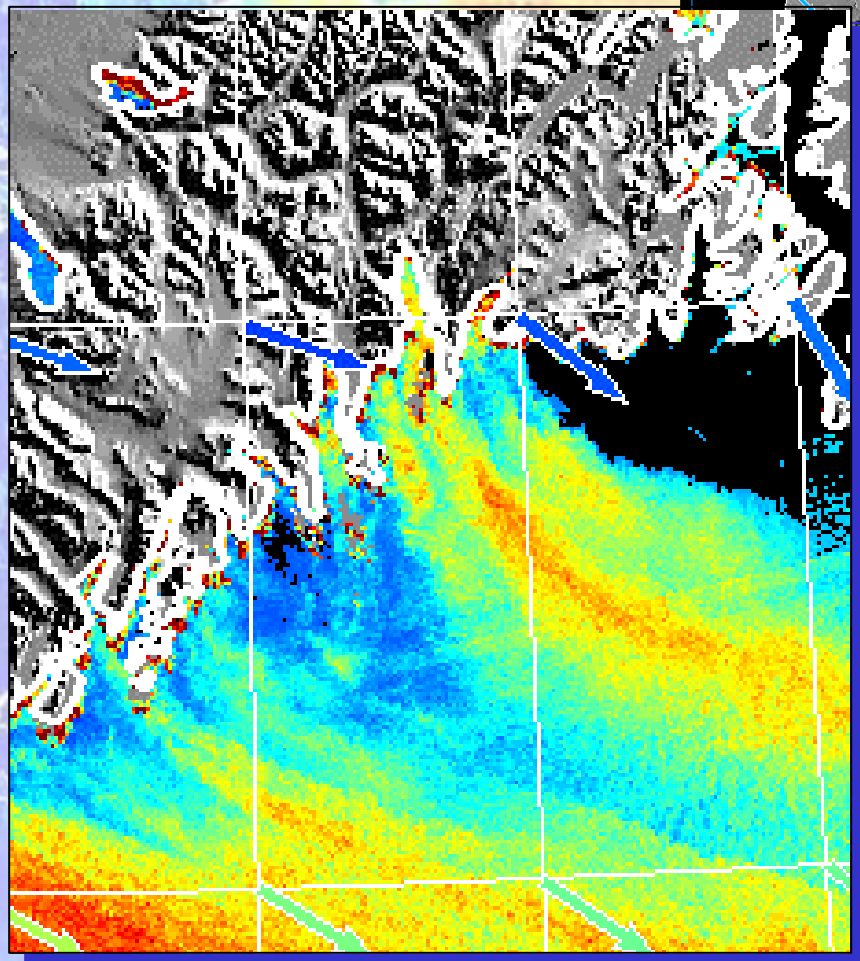
Closeup

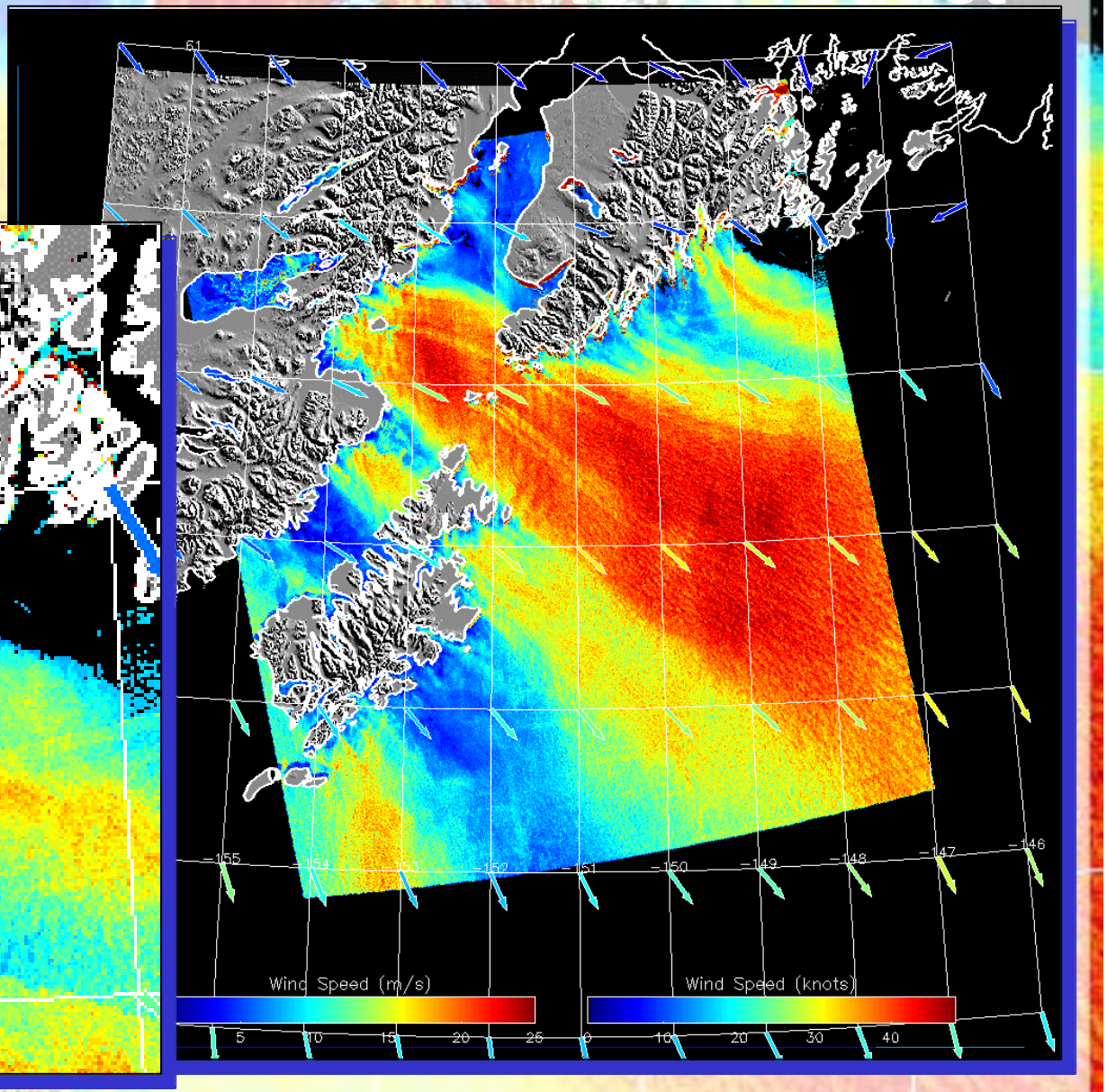


1999 Dec 24
0344 UTC

New Product

1999 Dec 24
0344 UTC





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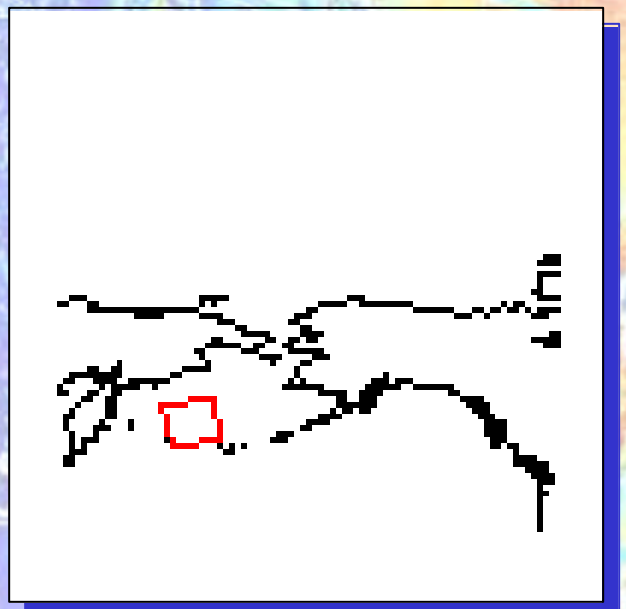
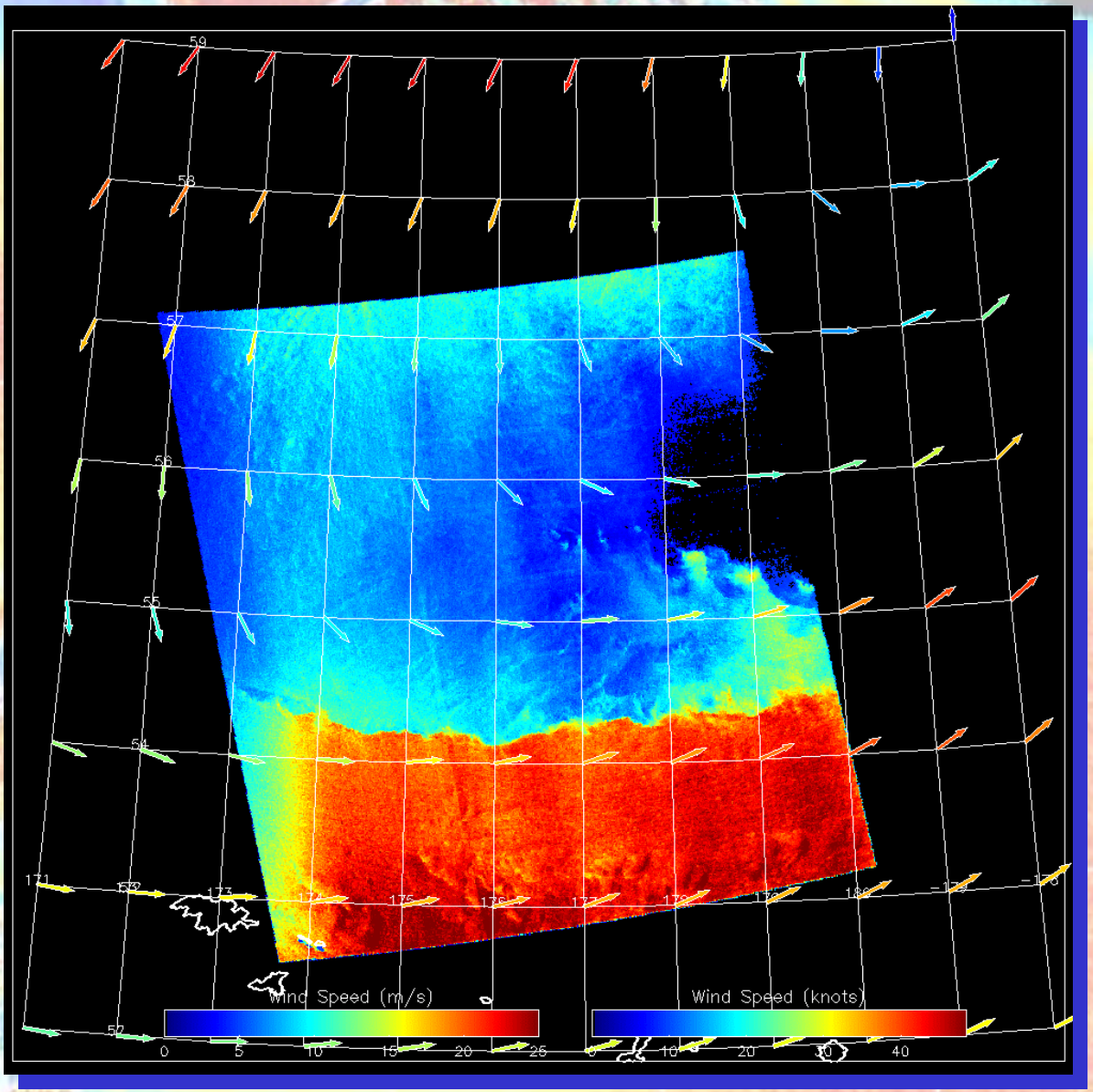
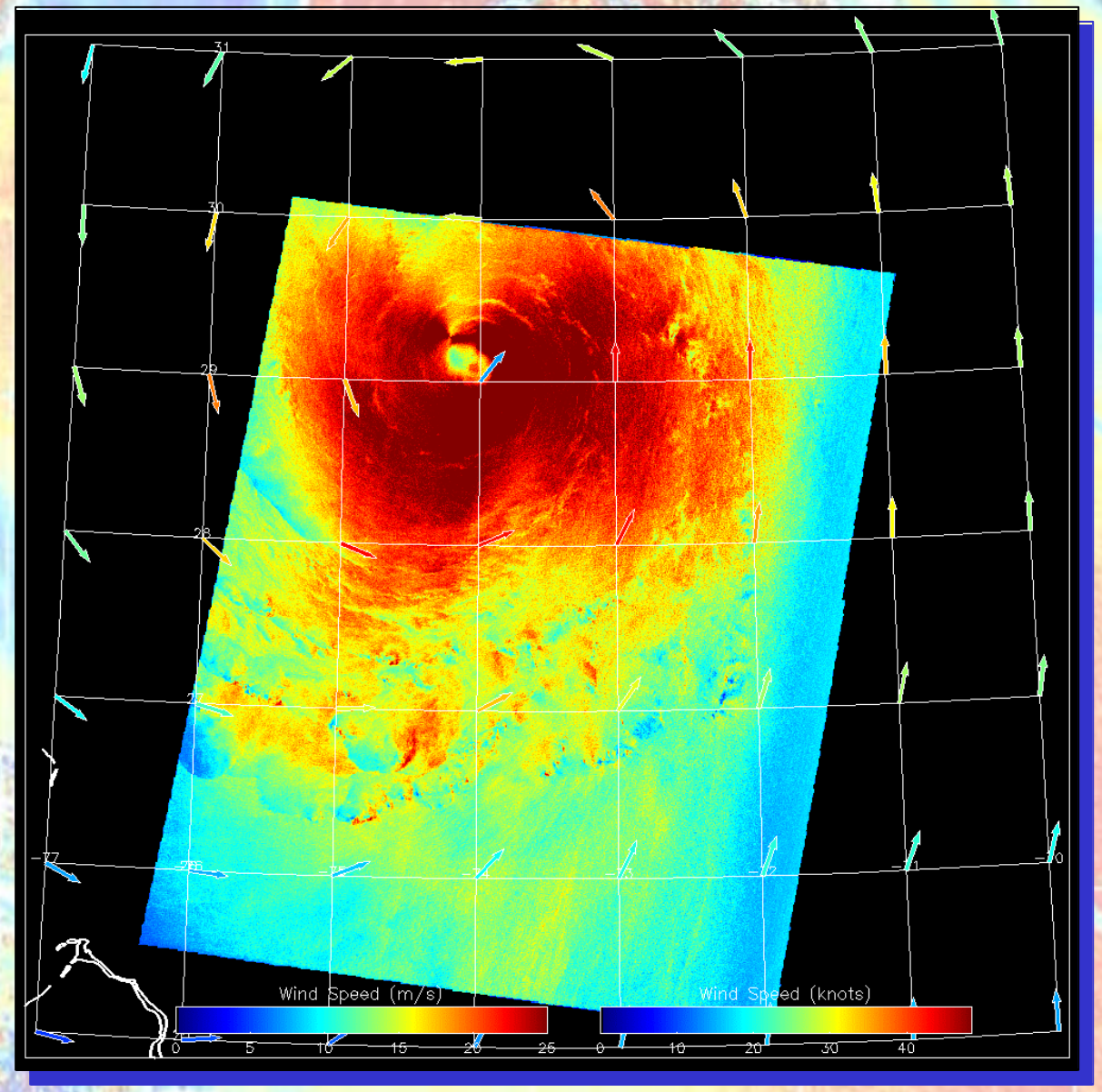
Low Pressure

2000 Feb 2
0557 UTC





Hurricane Danielle



1998 Aug 31
1053 UTC

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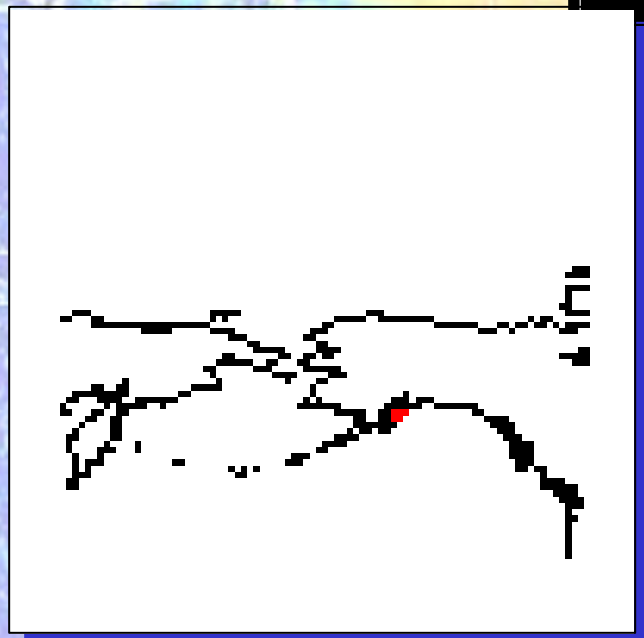
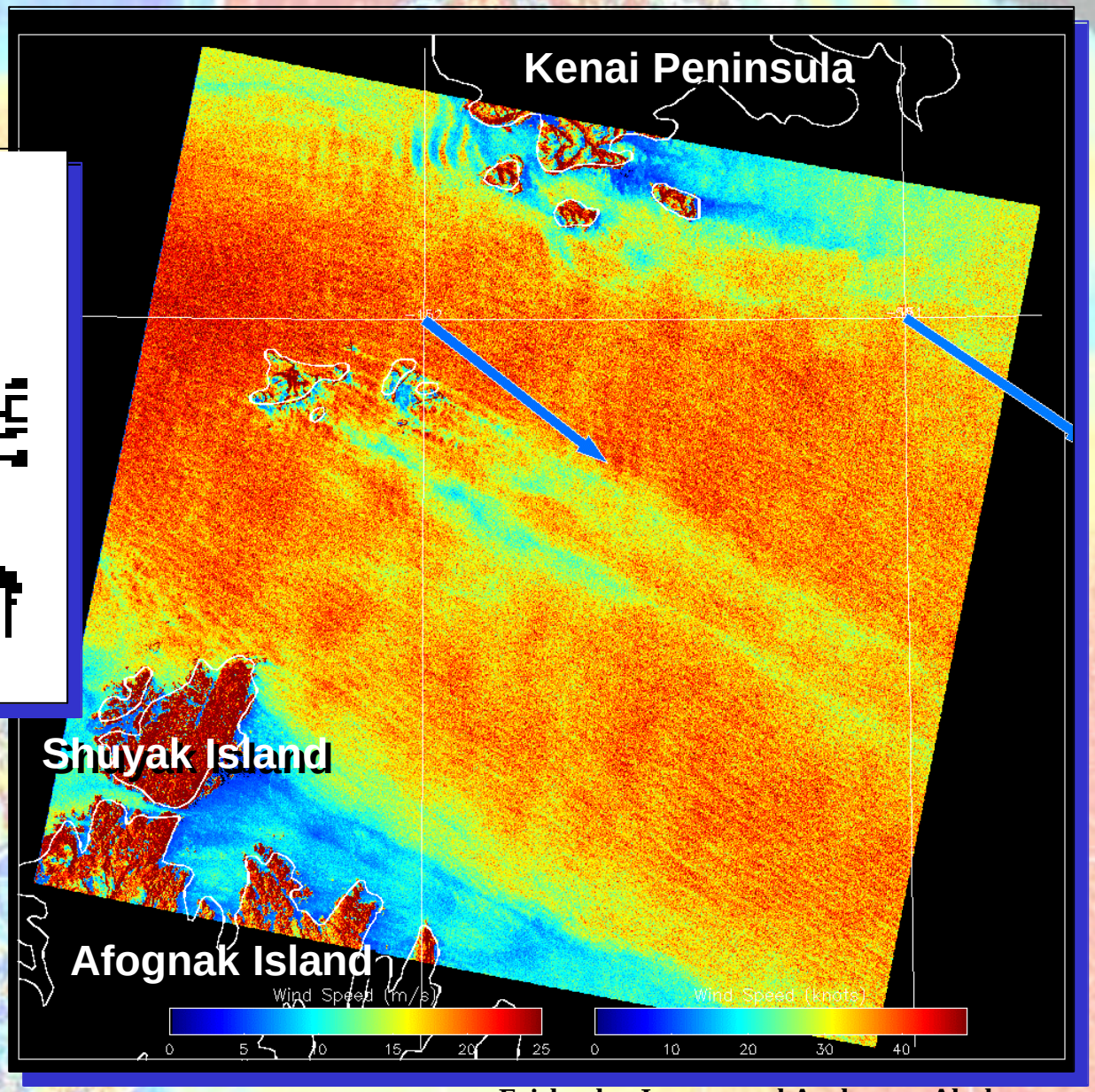
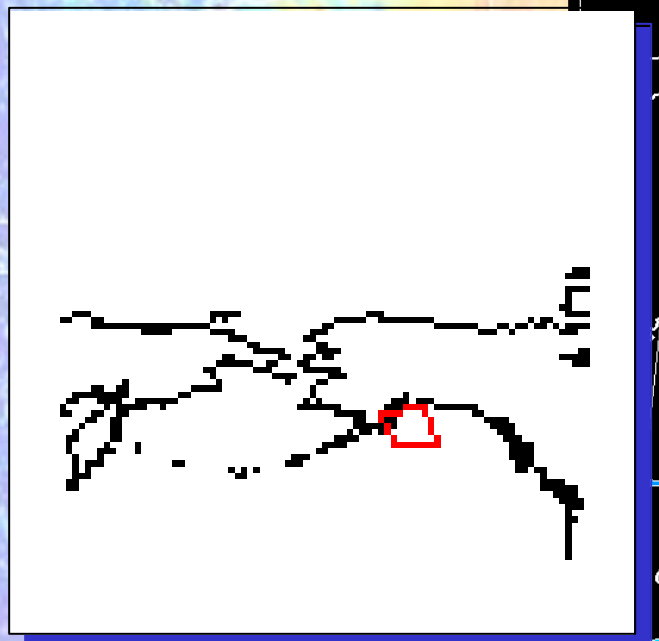
Standard Mode

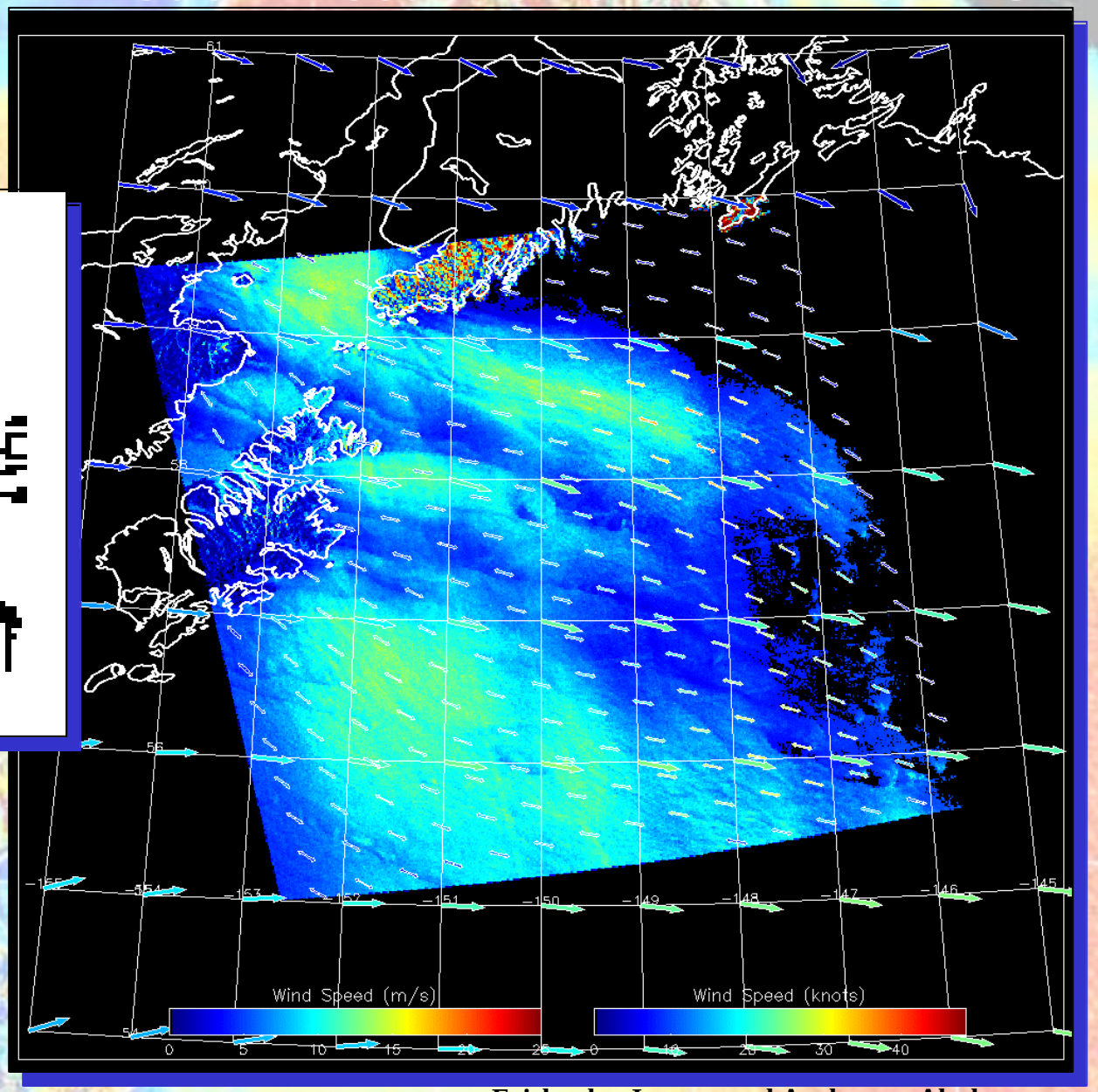




2000 Aug 22
1628 UTC

Model Directions vs SAR Directions





2000 Apr 05
0339 UTC

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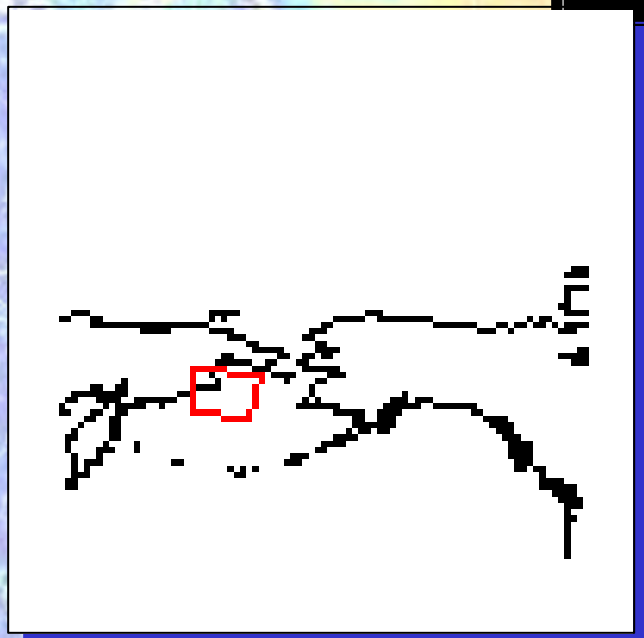
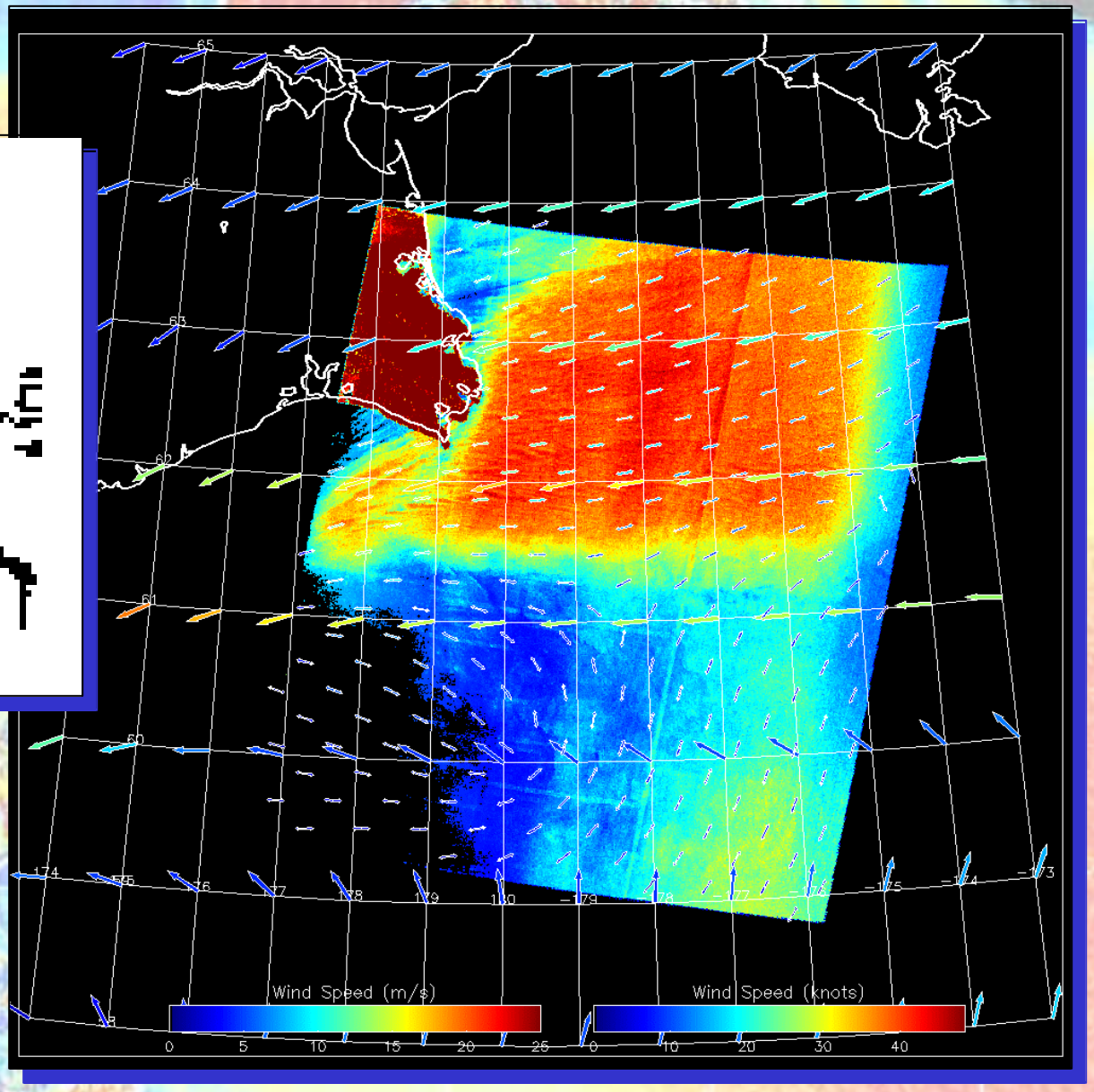
Model Directions vs. SAR Direction





2000 Apr 25
1821 UTC

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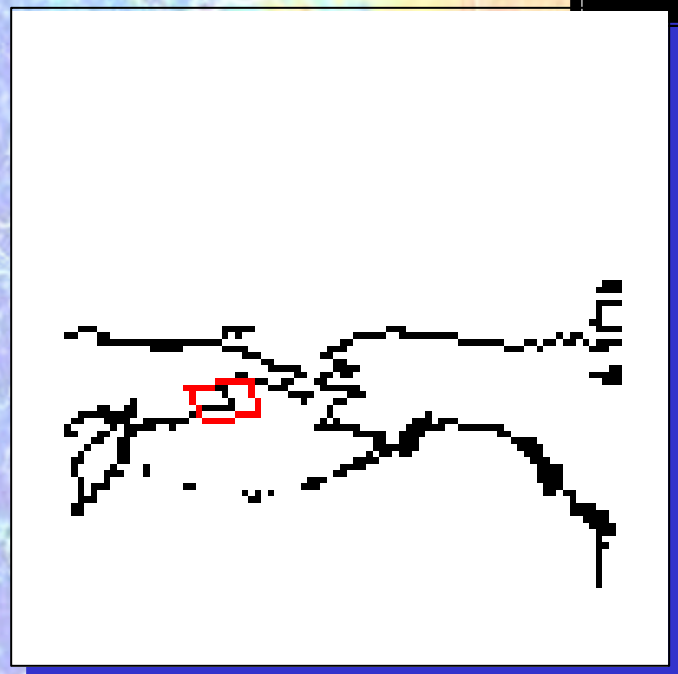
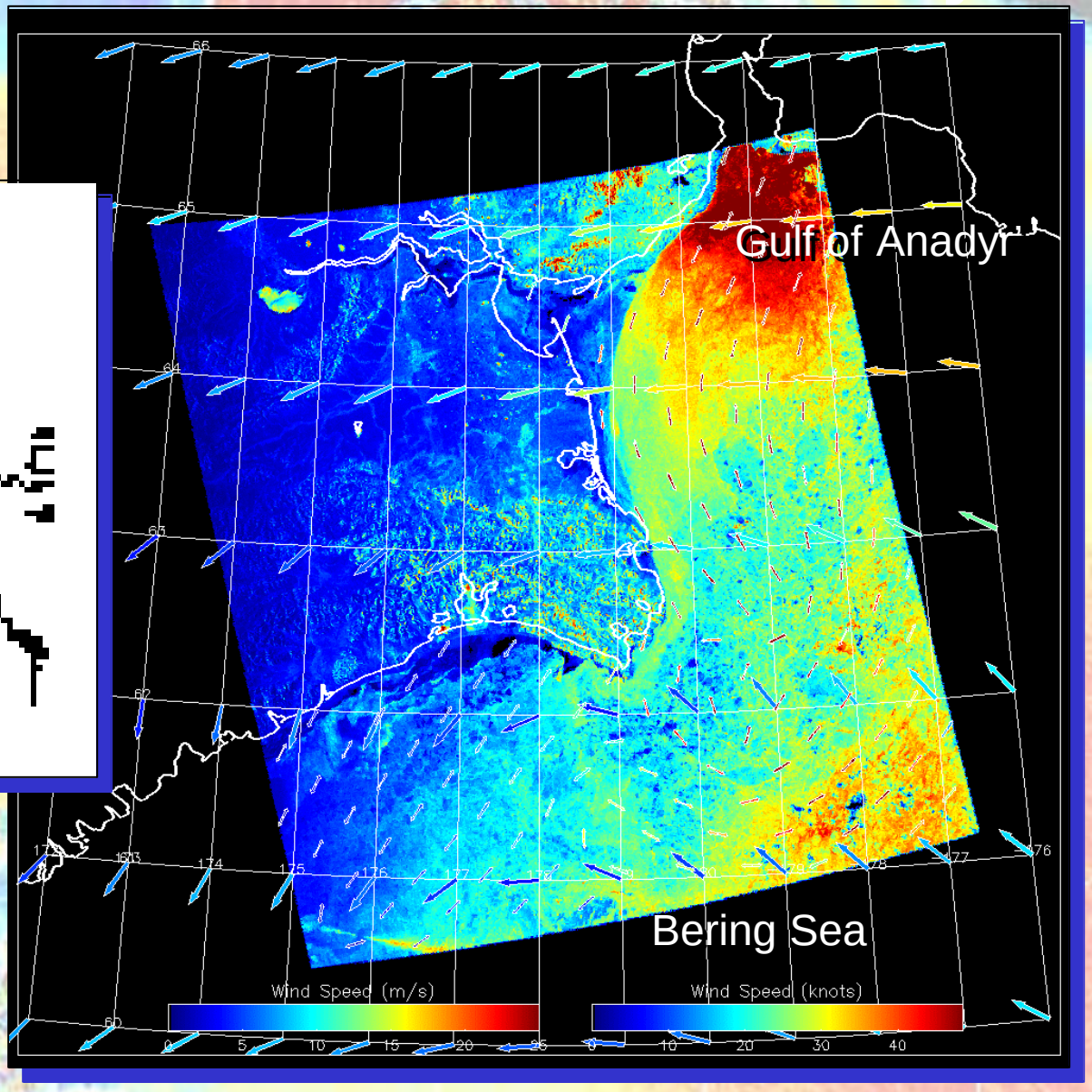
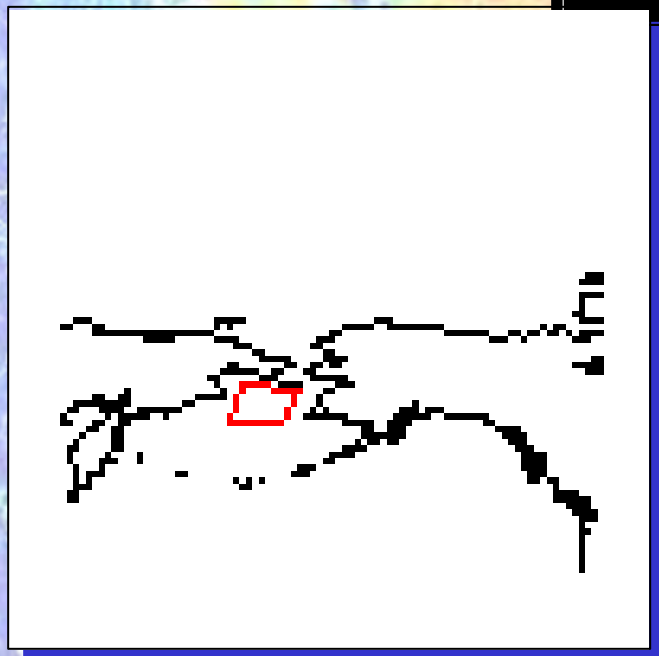
Ice in the way

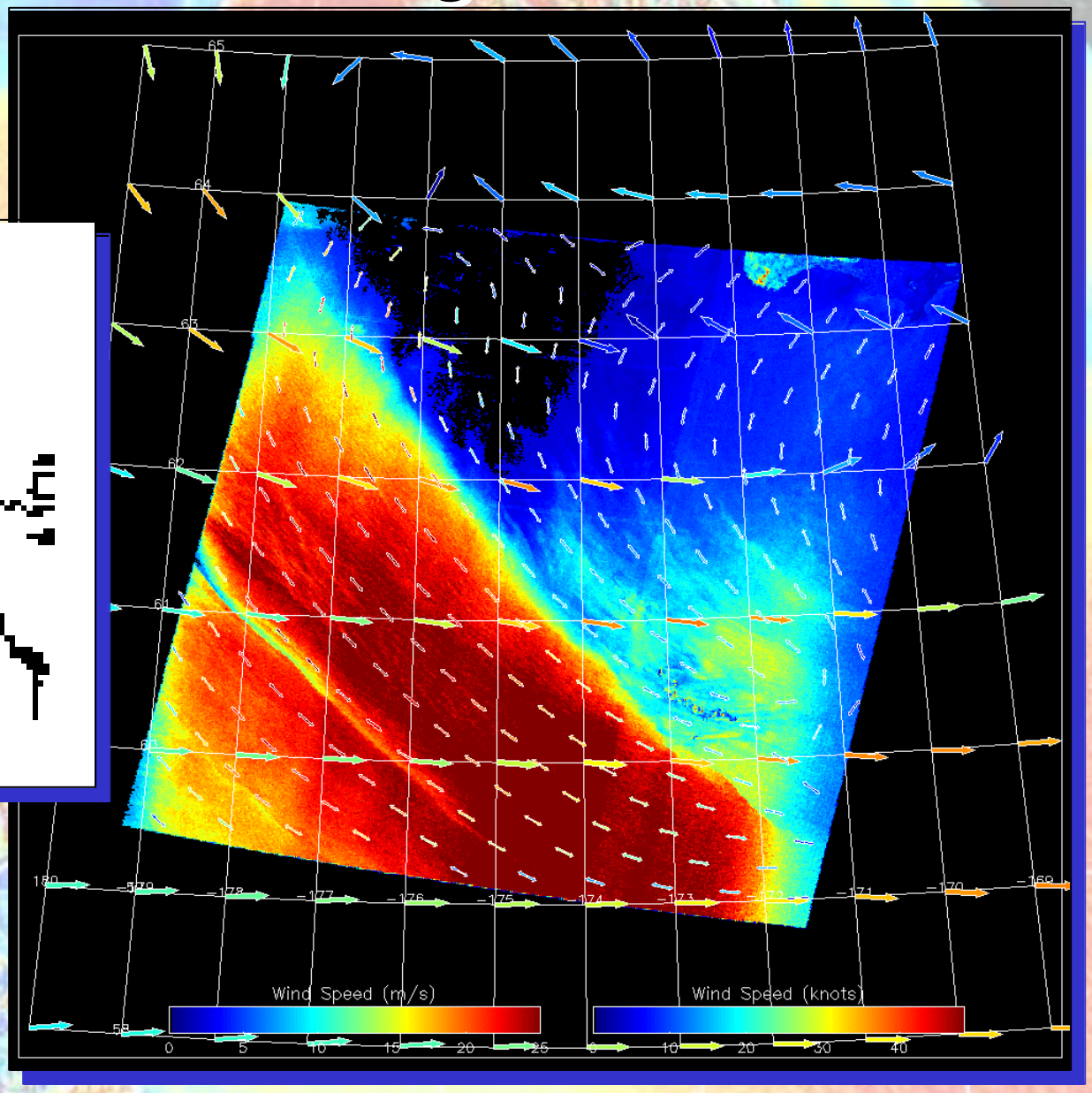




2000 Mar 08
0538 UTC

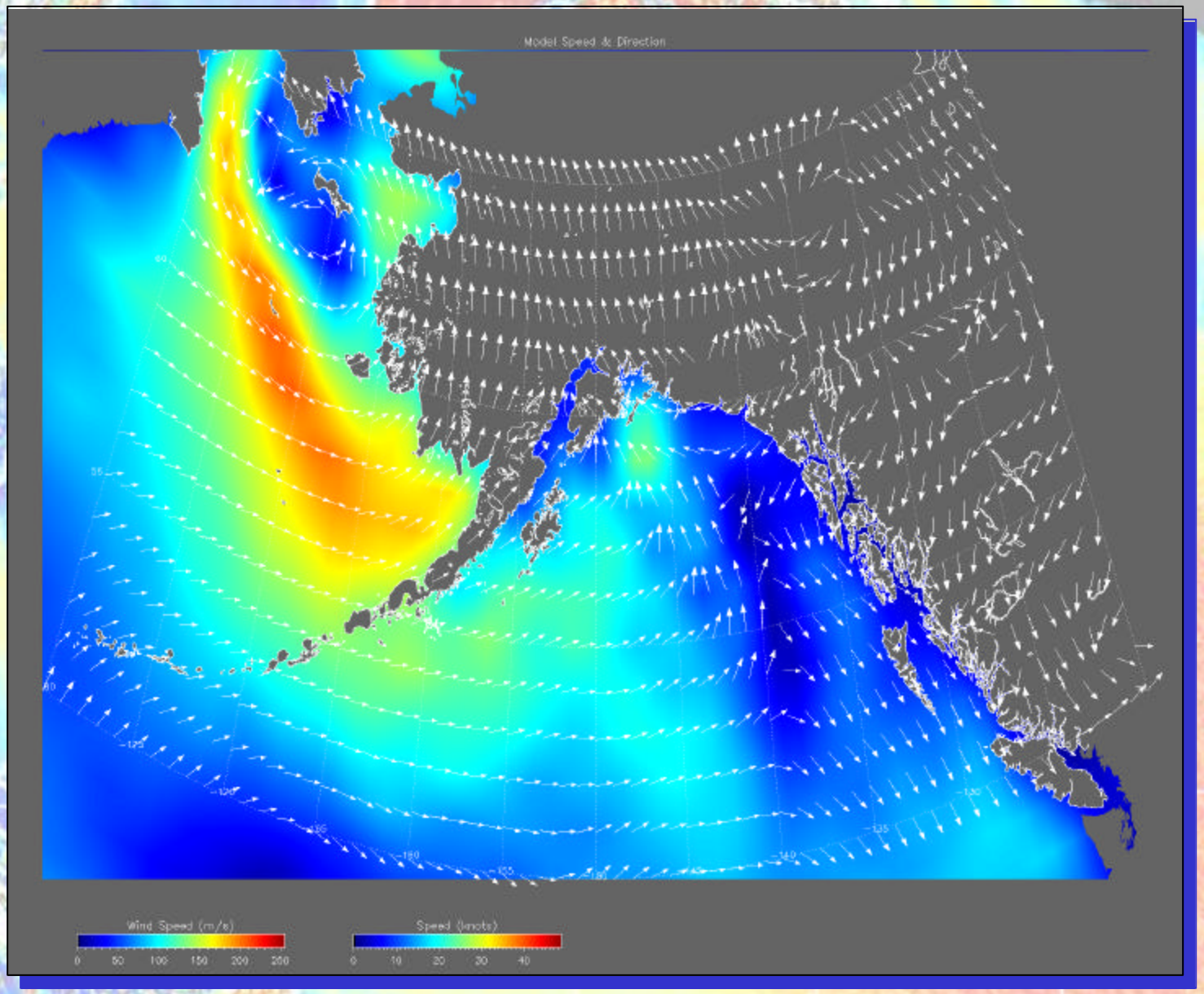
Examining a low





2000 Aug 29
1804 UTC

Model Field



2000 Aug 29
1200 UTC
t=0600

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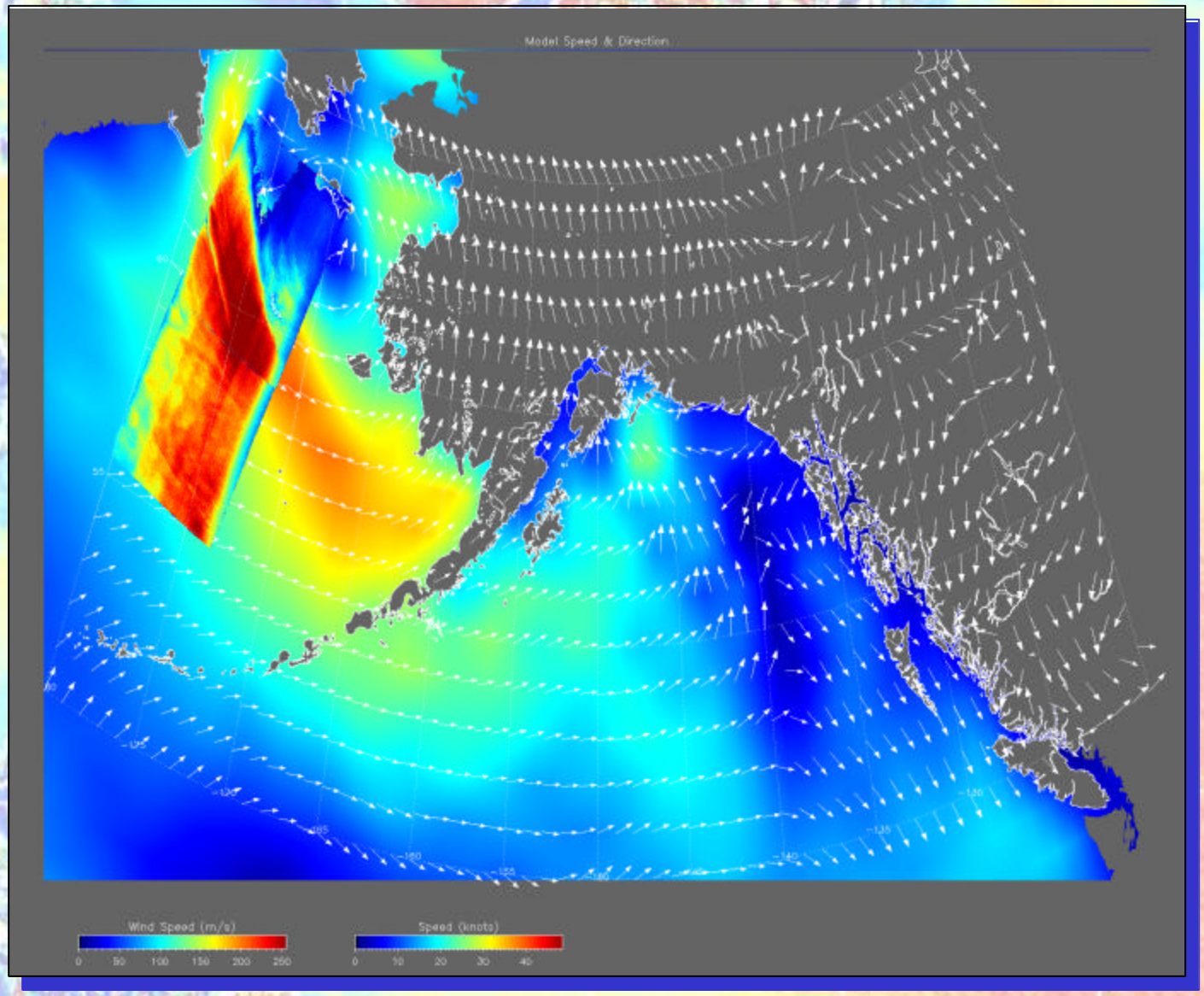
SAR & Model



2000 Aug 29
1804 UTC

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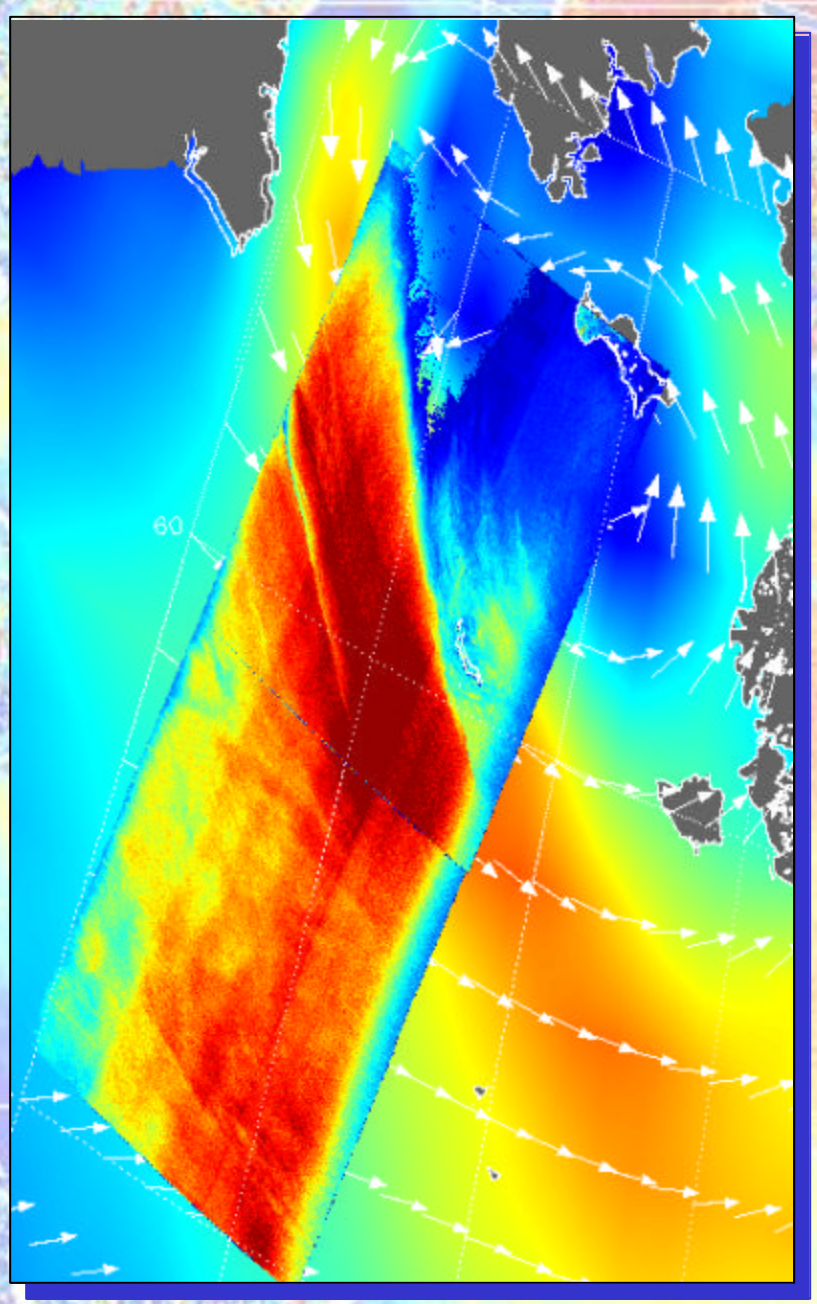
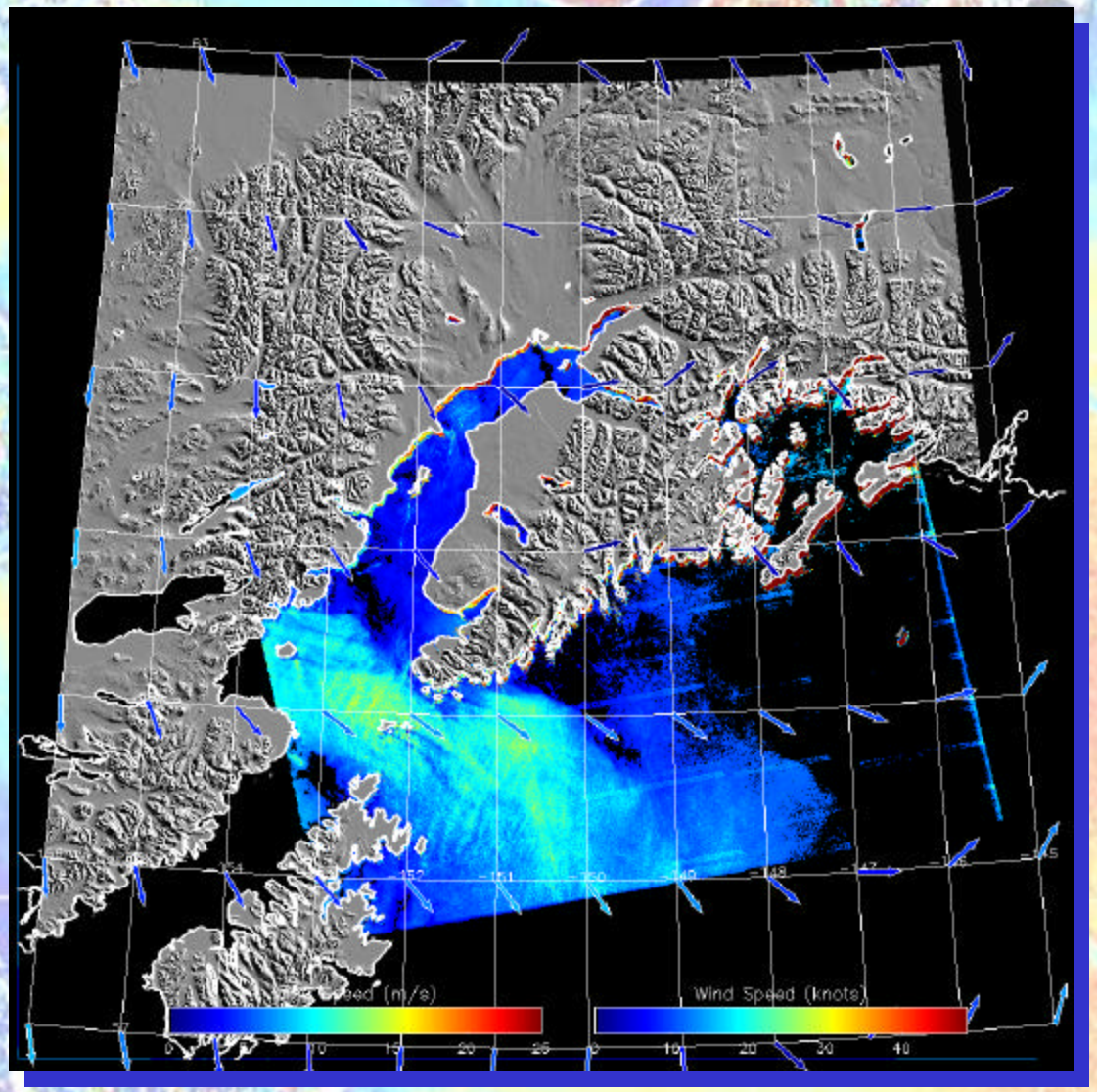


SAR & Model (Enlarged)

2000 Aug 29
1804 UTC

September 27, 2000 0336



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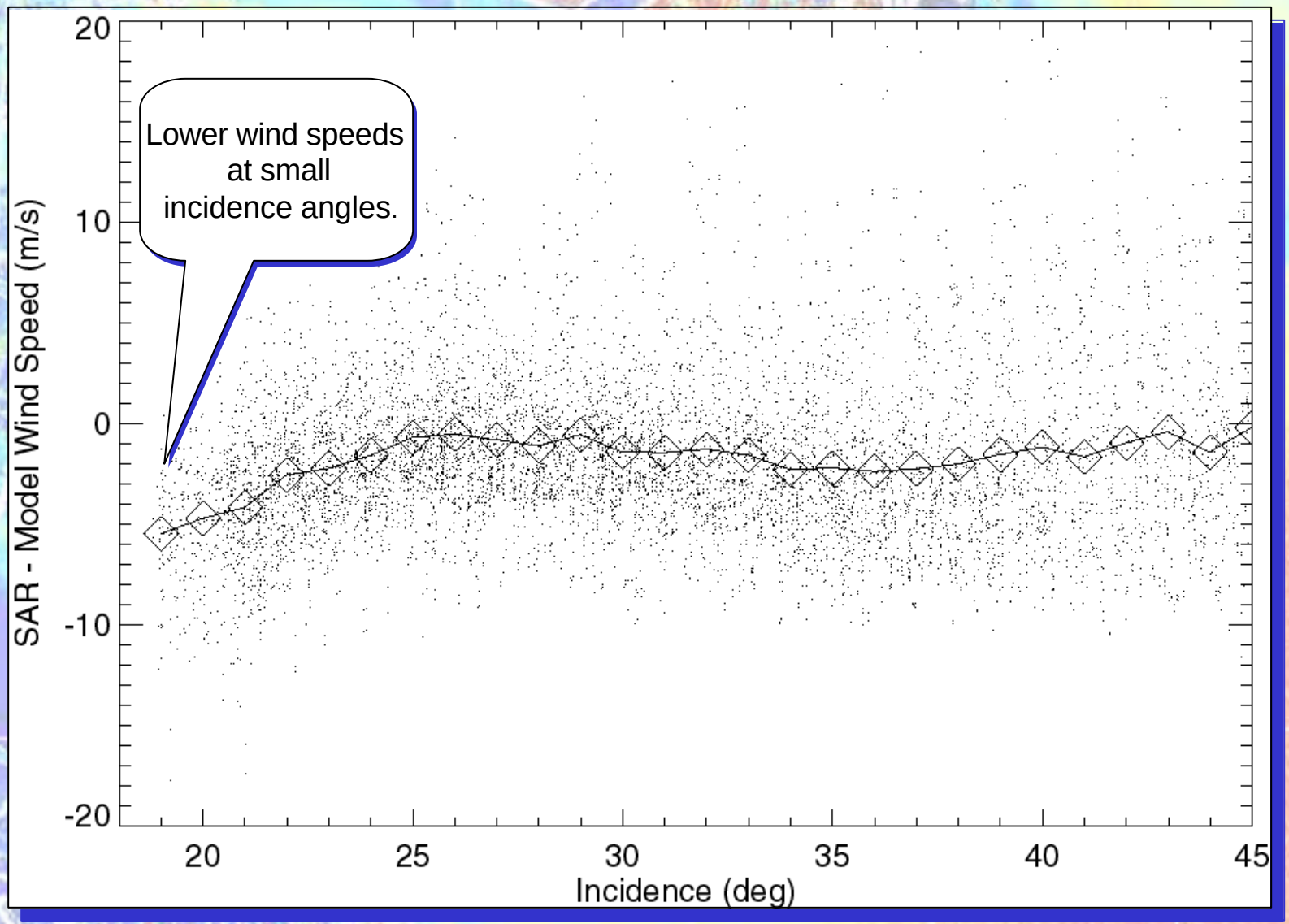
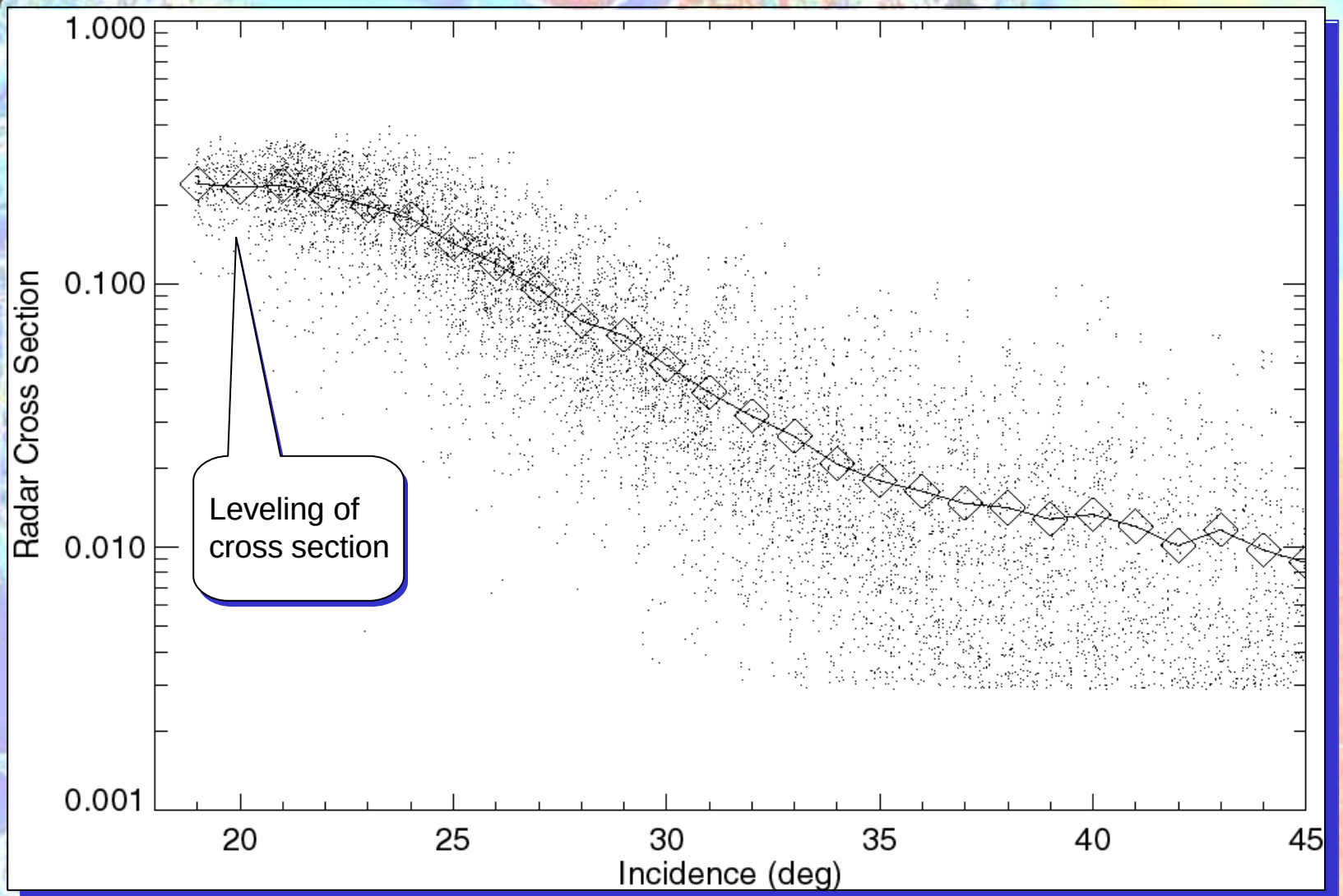
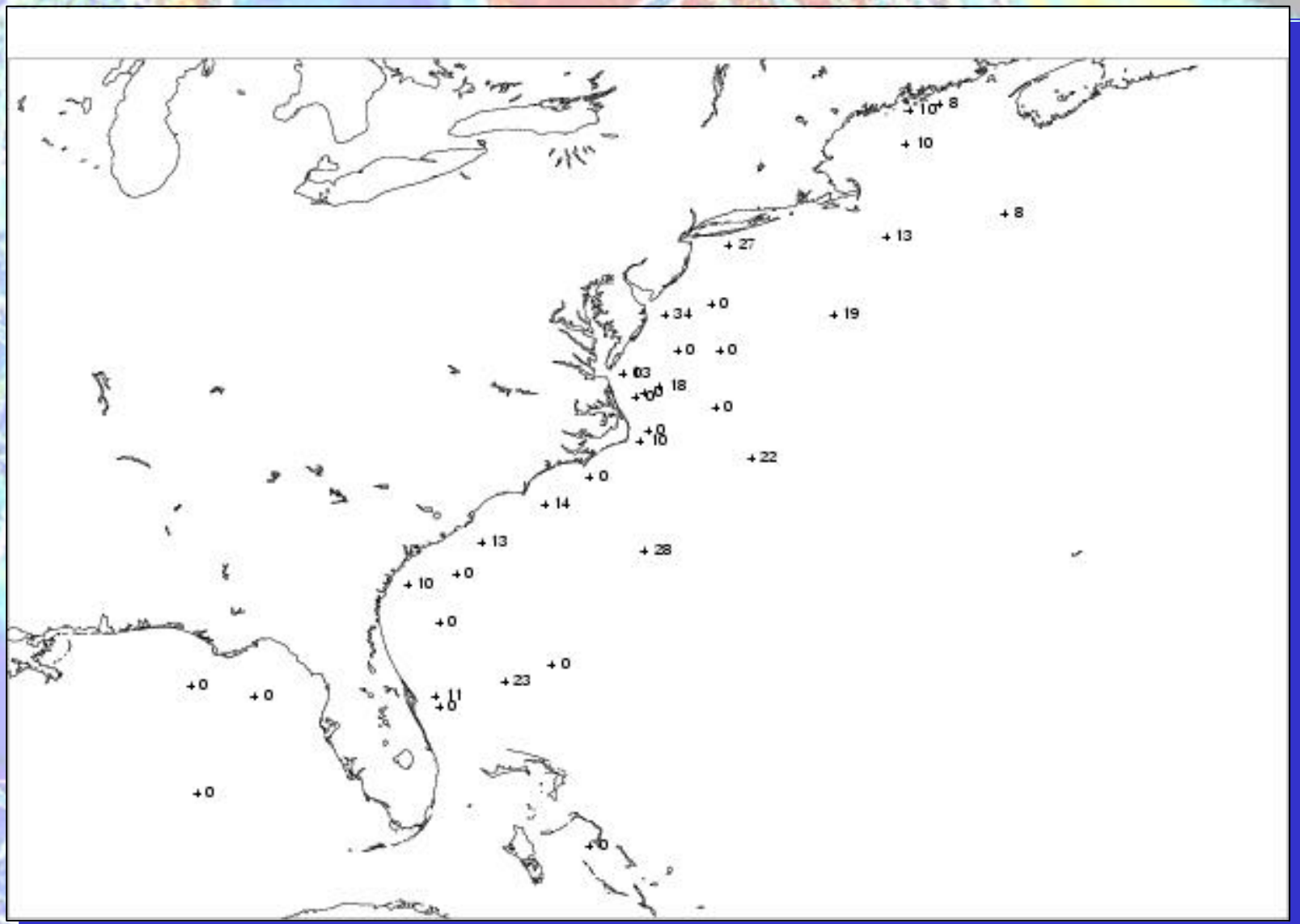
Model v. SAR Wind Speeds



Cross Section vs Incidence



East Coast Buoy Coverage



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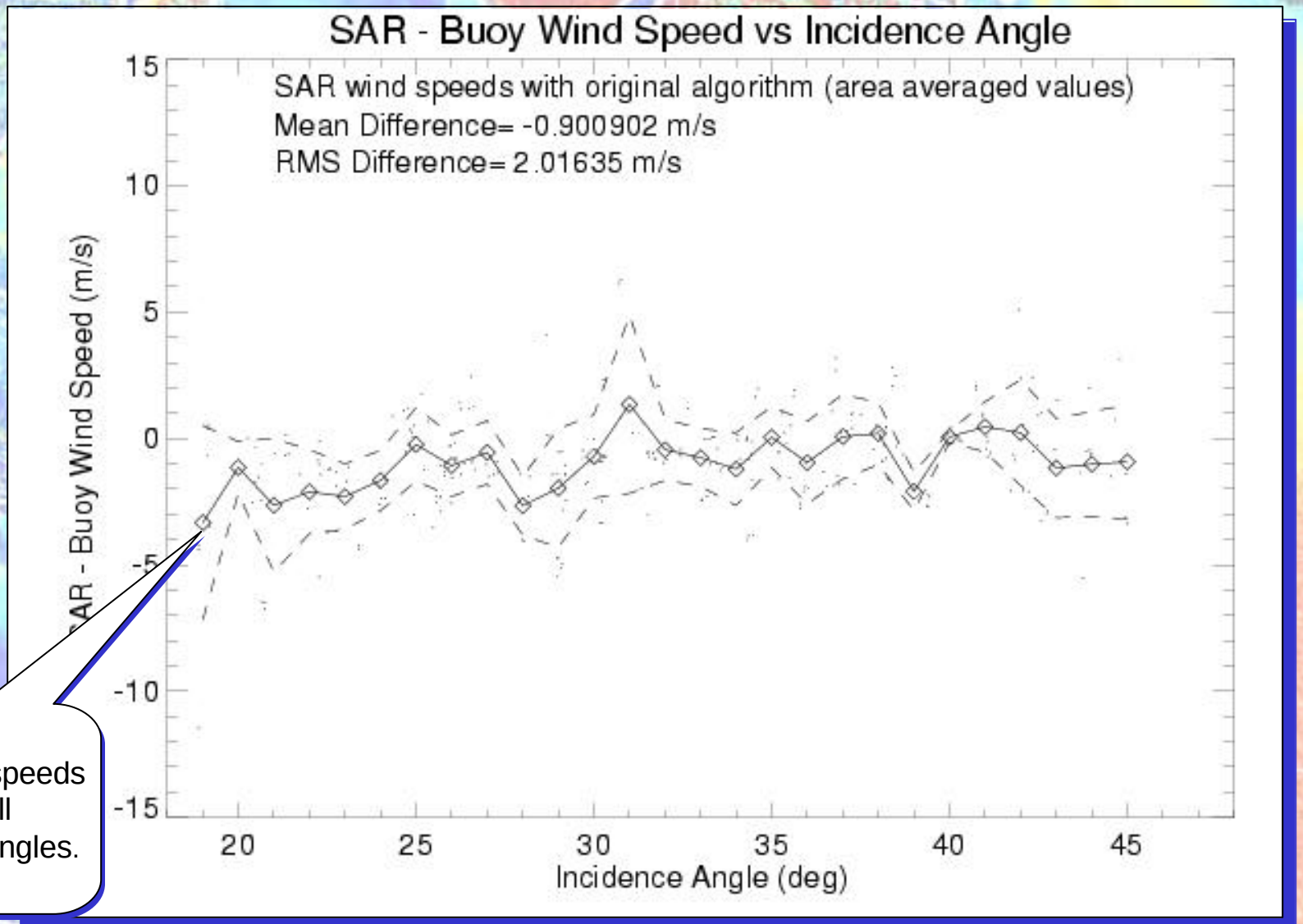
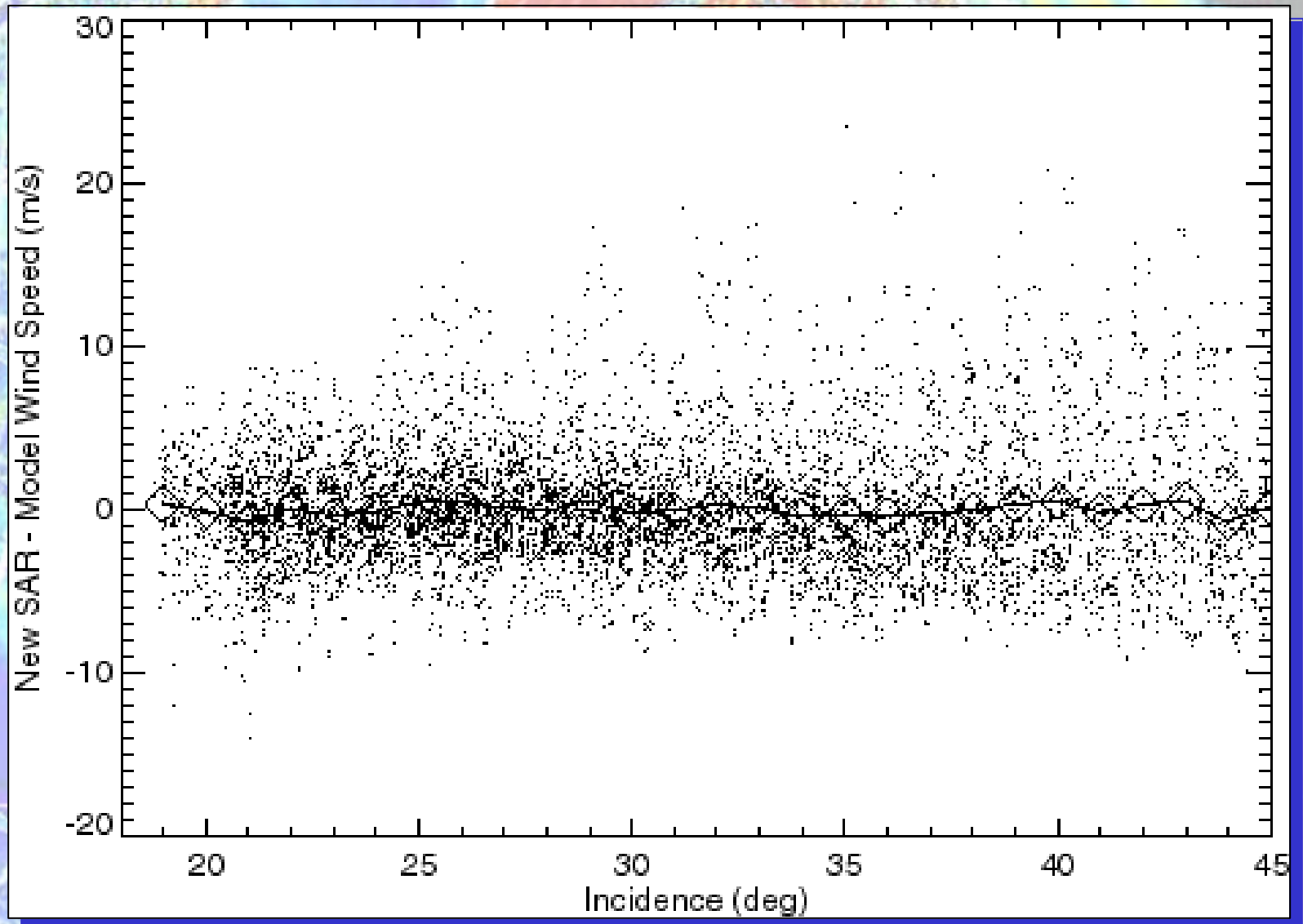
Comparison with buoys

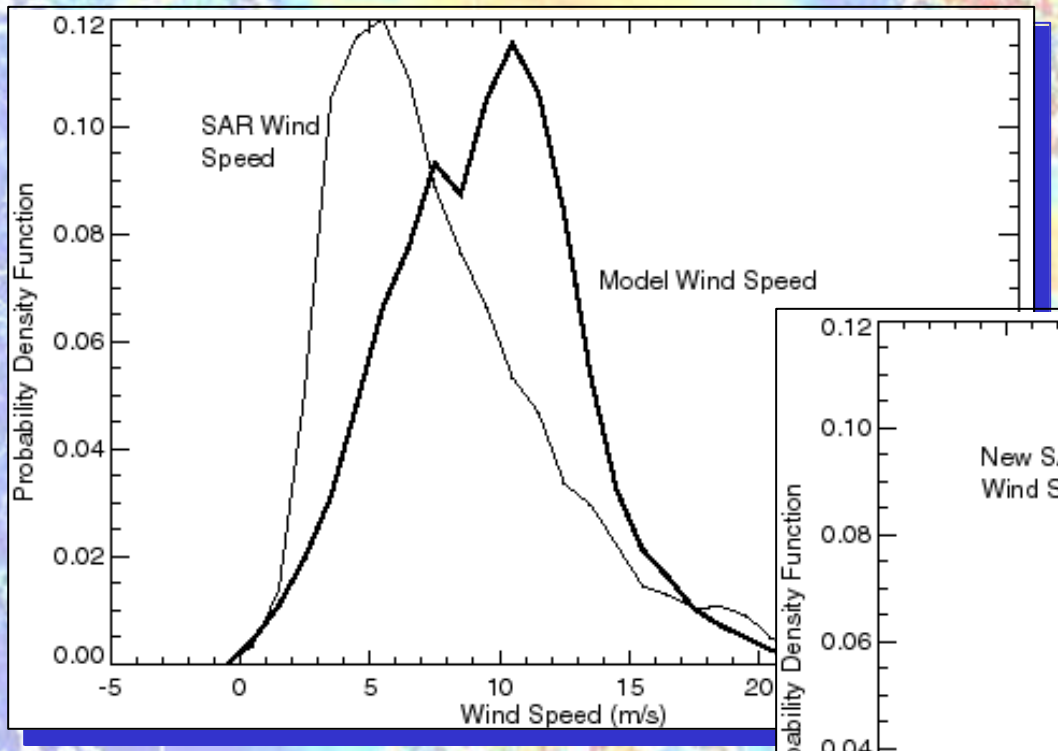


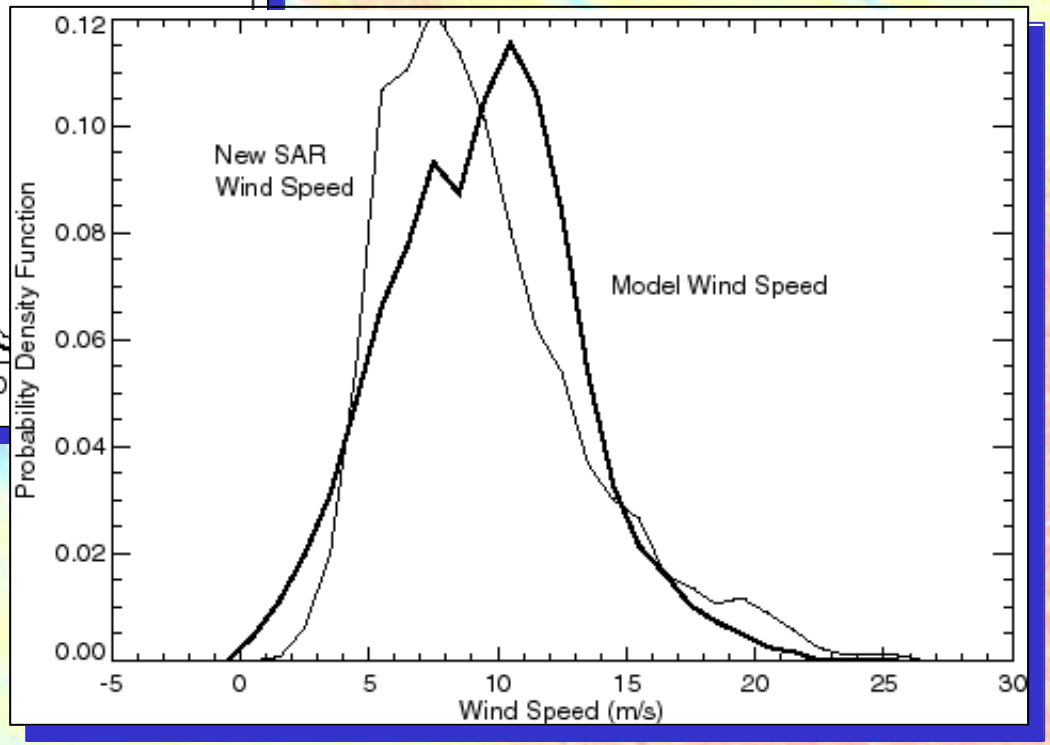
Lower wind speeds at small incidence angles.

Ad Hoc Correction



Wind Speed Distributions





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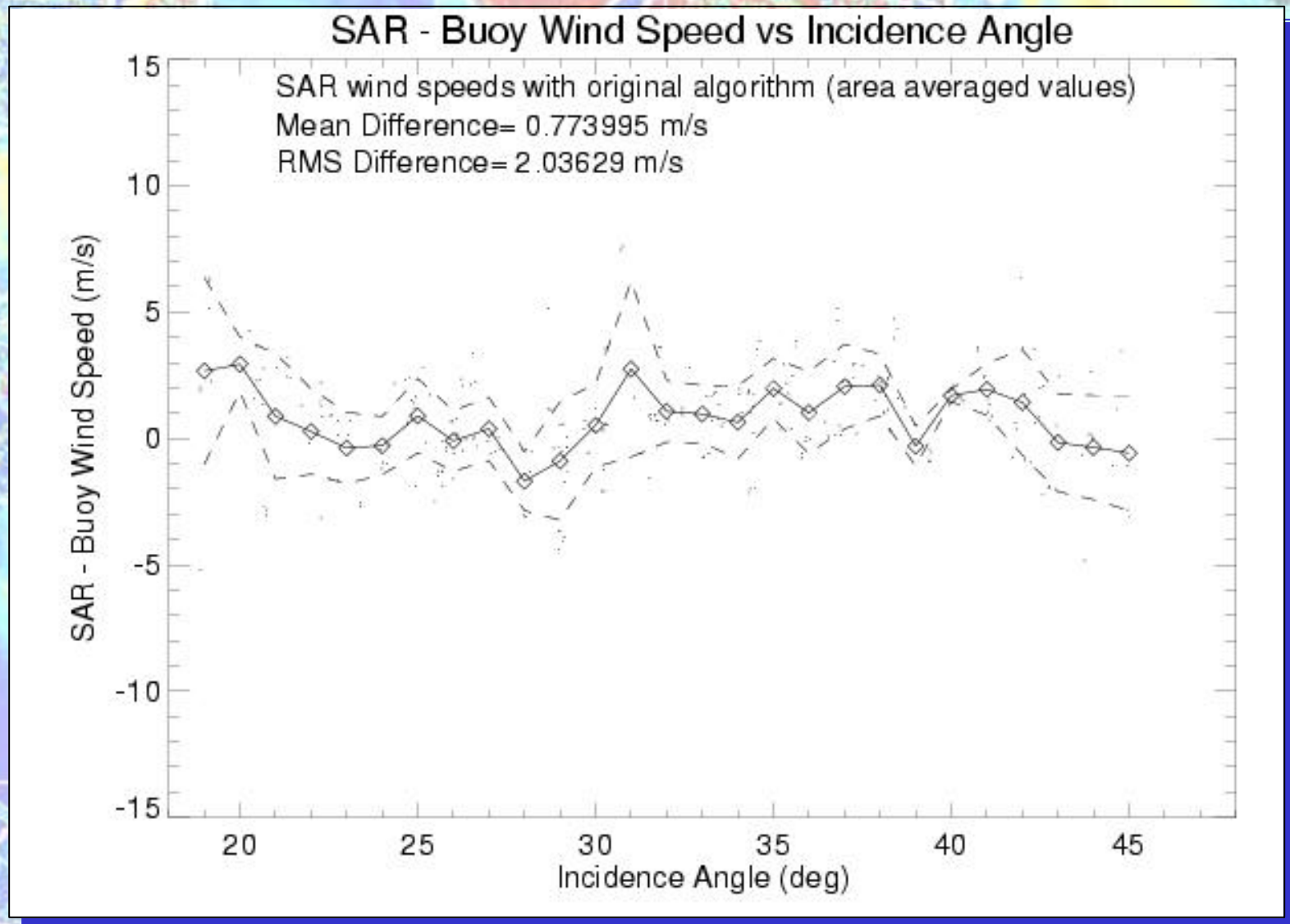
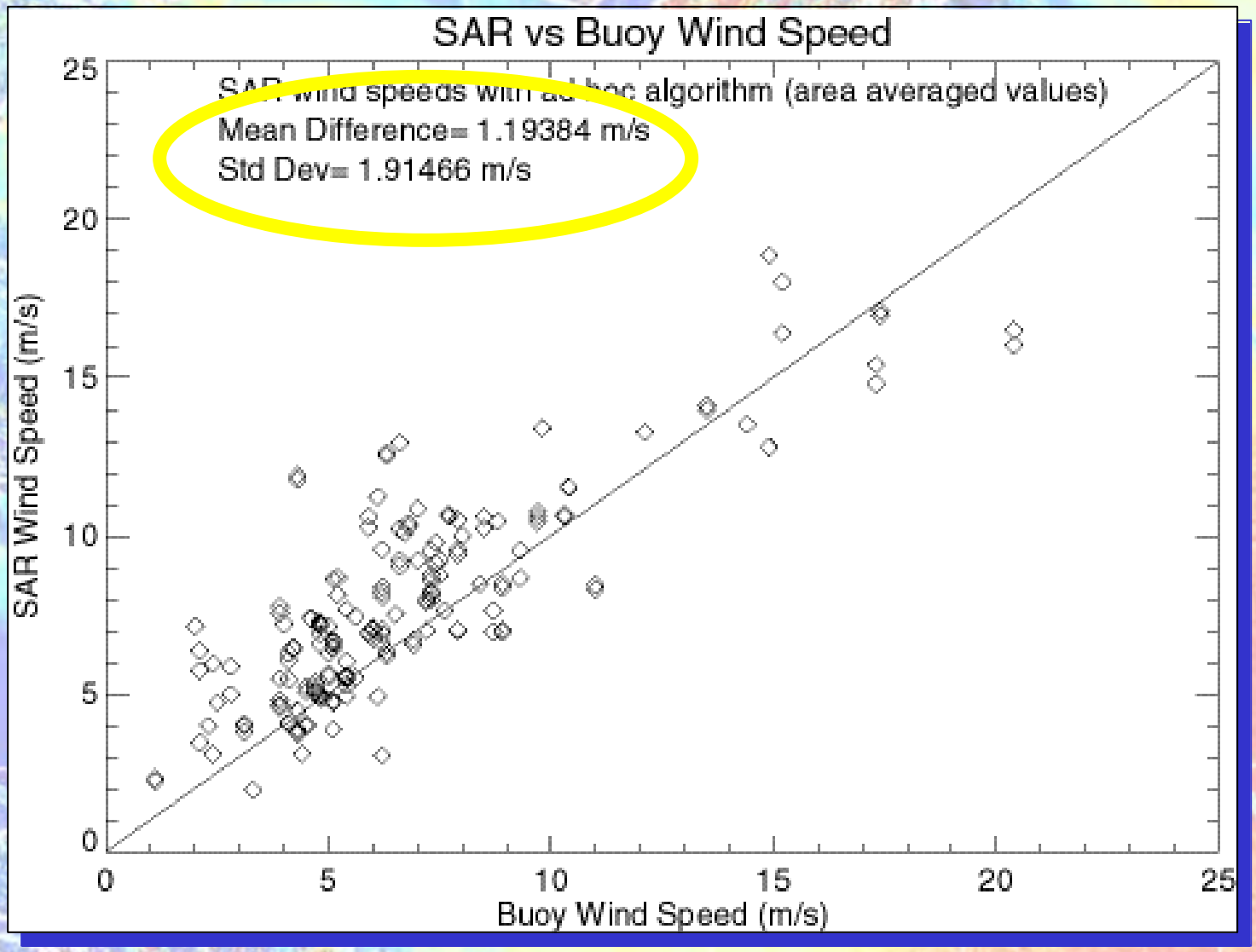
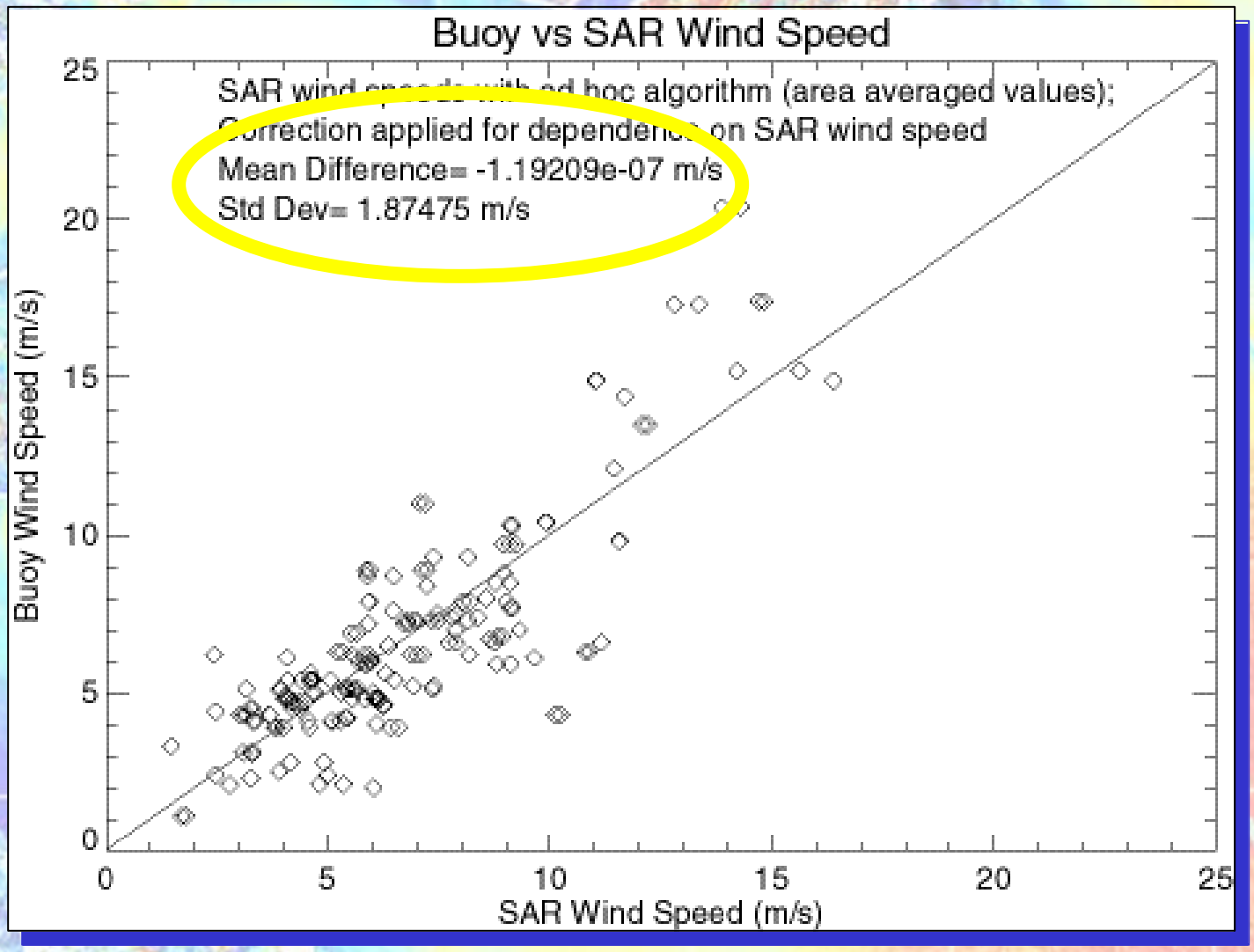
Buoy Comparison



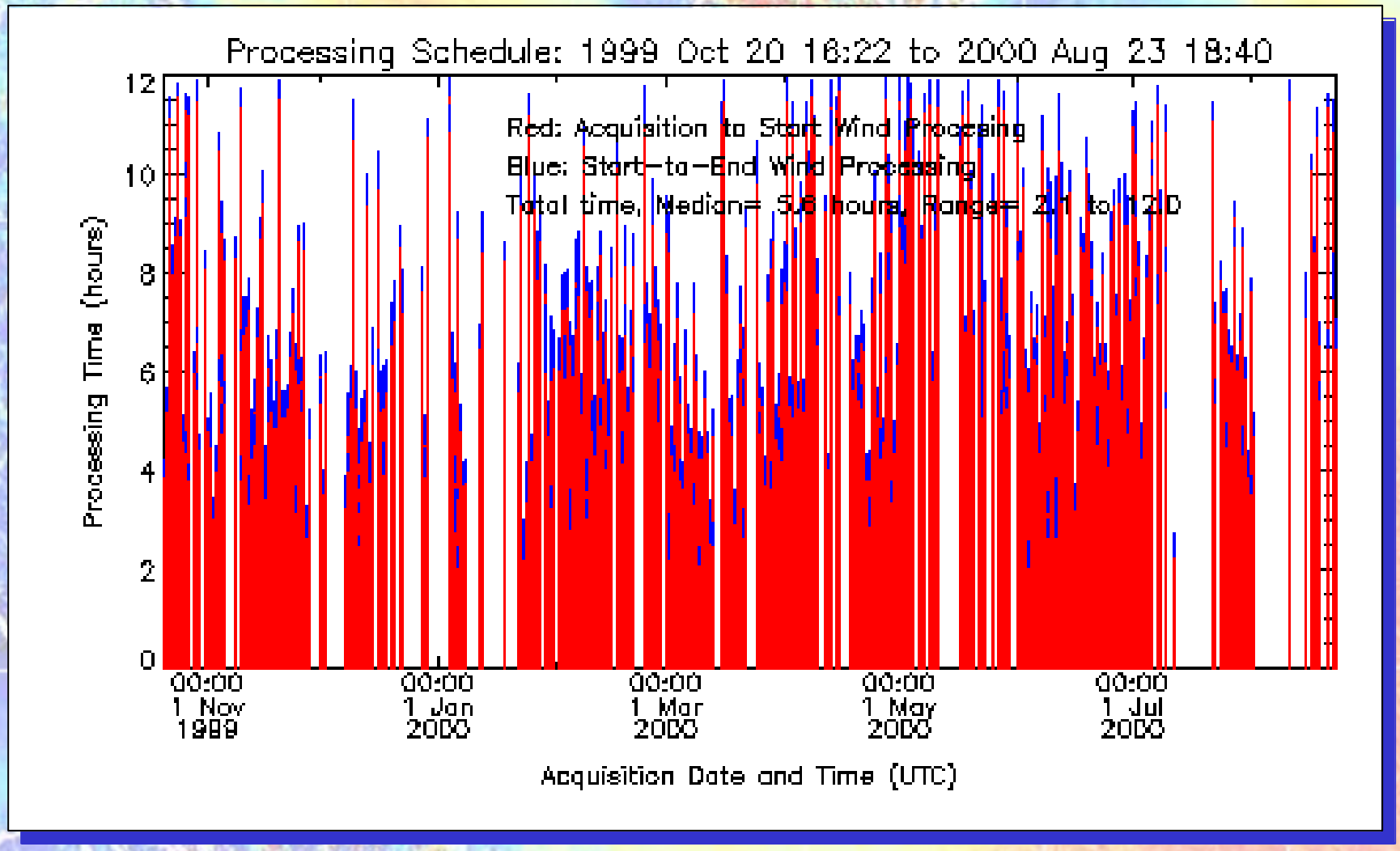
Direct Buoy-SAR Comparisons



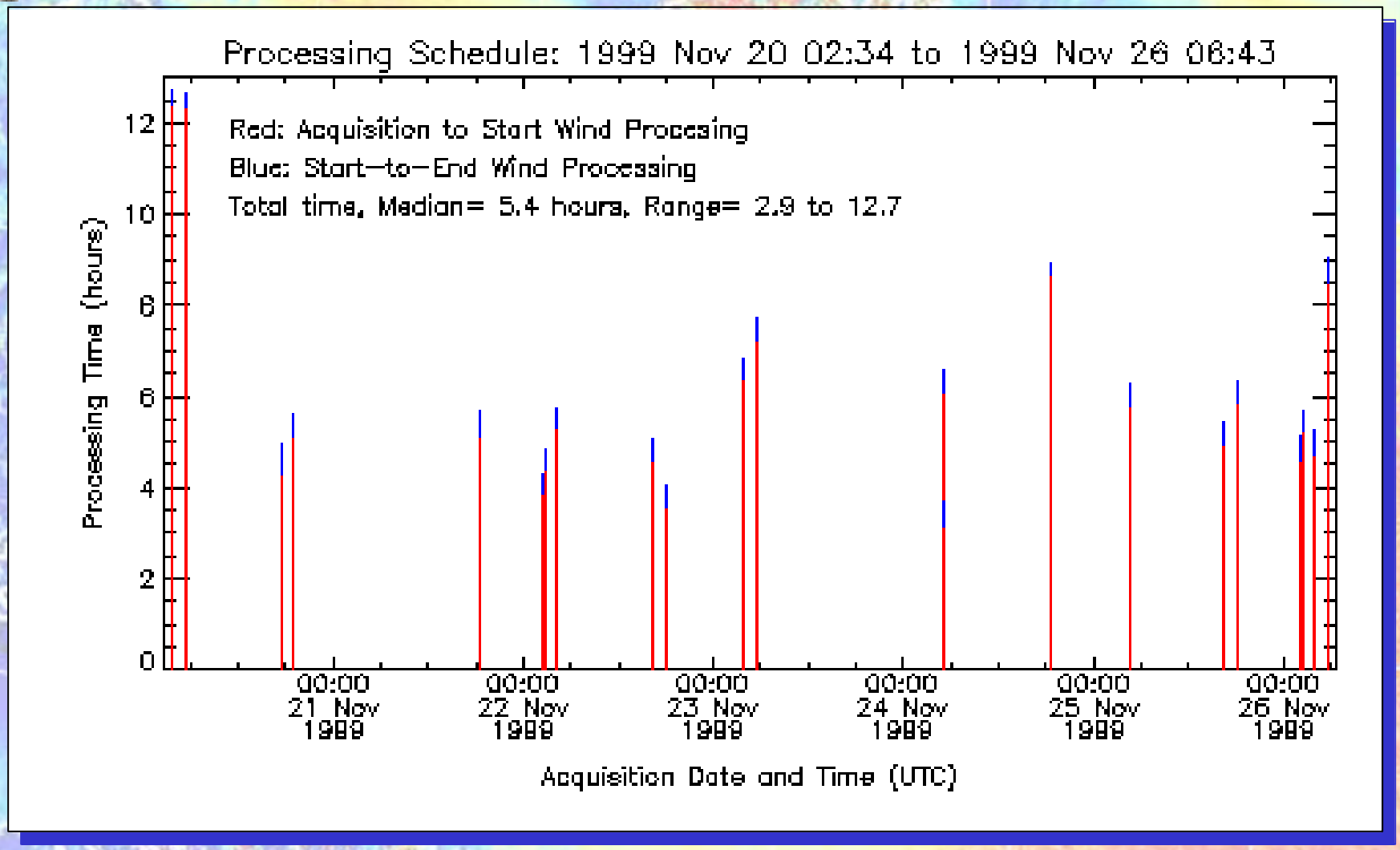
Direct SAR-Buoy Comparisons



Timing Excluding Times Over 12 Hours



A Good Week


Processing Schedule: 1999 Nov 20 02:34 to 1999 Nov 26 06:43
Red: Acquisition to Start Wind Processing
Blue: Start-to-End Wind Processing
Total time, Median= 5.4 hours, Range= 2.9 to 12.7
Processing Time (hours)
0
2
4
6
8
10
12
00:00 21 Nov 1999
00:00 22 Nov 1999
00:00 23 Nov 1999
00:00 24 Nov 1999
00:00 25 Nov 1999
00:00 26 Nov 1999
Acquisition Date and Time (UTC)

Conclusions

- It is possible to produce high-resolution wind speed estimates 5-6 hours from acquisition.
- We have observed structures unobservable with other instruments.
- Comparisons with model prediction raise calibration issues.
- Comparison with buoys show 2 m/s standard deviation.
- Future integration of wind speed retrieval approaches.